

# HAWAII'S CROP PARADE

A Review of Useful Products  
Derived from the Soil in  
the Hawaiian Islands,  
Past and Present

By

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## Agricultural Prospecting

Back of the wealth-producing mine is the prospector, that lone figure trudging mountain and desert, sampling here, there and everywhere, always hopeful that the next thrust of his pick will open a bonanza.

Back of our great agricultural industries, also, there is a long story of prospecting: the lone farmer trying many new crops, the pioneer company exploring the possibilities in new products and untried land areas, the investigator and experimenter seeking the best that science can make possible for industrial development.

The finding of a good crop plant or animal and the subsequent establishment of a profitable industry there-upon does not bring an end to this quest, for always there is the lure of the frontier, the creative margin, where the prospector continues his search for something new and better.

The value of this prospecting service does not lie in the possibility that an established industry may be displaced by one that is new and more profitable; the greatest value is the strengthening and stabilizing of the economic structure of a state or a nation by the increased diversification in agricultural industries which results from the prospector's discoveries.

Diversification of agriculture is a pressing problem in Hawaii, as in many other places. It is not a new problem, however, for much effort has been expended during the past 150 years in experiments upon many different agricultural crops and industries here. A brief outline sketch of these attempts at diversification is offered in the following pages, but it tells only a little of the human side of the story—the hardships, the tragedies, the heartaches at failure, and the glow of satisfaction when efforts were successful; there have been losses of money, sometimes staggeringly large, sometimes small but no less serious to the loser, and there have been handsome profits: one hears of the profits but seldom of the losses, and it is easy to slip into the error of overlooking the expense side of the ledger.

There are several good reasons why agricultural industry in Hawaii should be of a diversified nature: (1) economic stability is strengthened when there are several major industries, instead of one, for it seldom happens that disaster overtakes all simultaneously and in the same degree; (2) our geographical isolation is less acutely felt in time of strikes or wars which cut off shipping, if we are producing things which can be used to sustain life during the emergency; (3) the islands are so greatly diversified in topography, climate and soil types that diversification of agriculture is perfectly logical and natural, indeed almost inevitable.

The Hawaiian archipelago is situated just within the tropics, the northern island, Kauai, being only a relatively few miles south of the Tropic of Cancer. The geographical center of the island group is on about the same latitude as Cuba and Formosa.

Throughout most of the year the Hawaiian Islands are cooled by the trade winds blowing from the northeast, and consequently the average climate is a little less tropical than it otherwise would be. Geographers<sup>1</sup> place the archipelago in the isotherm of 68 degrees. This, however, is only the mean; from one locality to another the range of variation from the mean may be very extensive, for within a few miles one can pass from a humid, tropical climate at sea level to almost arctic cold at the top of high mountains.<sup>2</sup>

Topography varies widely: there are the broad, smooth, flood plains and large, sloping shoulders between gulches and canyons, where power machinery may be used to good advantage; there are very fertile valley bottoms, too small for large-scale operations, but excellent for small farming; there are steep slopes which must be terraced; there are vast areas where lava flows of the past few centuries are still in the process of disintegrating into agricultural soil, and as yet capable of being farmed only in scattered spots and only by hand implements; there are extensive areas which because of the steepness of slope and rockiness of

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<sup>1</sup>See Coulter, J. W.—“Land Utilization in Hawaii,” Univ. Hawaii Research Publ. No. 8, 1933, p. 57.

<sup>2</sup>For a discussion of the variability of Hawaiian climate see *The Geographical Review*, Vol. 27, pp. 112-119, 1937 (S. B. Jones).



the ground are suited only to be used as pastures for cattle and sheep.

In soils, too, there is very great diversity. Some are of coral origin and strongly calcareous, while others have been formed by the disintegration of basaltic lava. Even among these latter there is great variation, for successive lava flows brought forth from the interior of the earth materials of great diversity in chemical and physical constitution.

Except<sup>3</sup> in a few unusual and generally unimportant situations, soil alkalis have never been a problem in Hawaiian agriculture. In general the island soils have been formed under conditions of such intense rainfall that alkaline materials are leached from the weathering rock as quickly as they appear in a soluble form. Such a process coupled with the adequate drainage provided by the porous and fissured rock of the mountain masses permits the removal of toxic materials before deleterious concentrations can be reached. Of course, beneficial materials such as potash, calcium and perhaps phosphorus may be lost by the same means. As a result, Hawaiian soils are not particularly nor continuously productive unless mineral fertilizers are used. But this low natural fertility is partially offset by freedom from troubles due to accumulations of toxic materials.

General as this conception may be to the great bulk of Hawaiian soils, particularly those of the uplands, certain exceptions should be noted. In some limited areas agricultural land has been reclaimed from salt marshes near the sea by conventional drainage procedures. Here a saline ground water table may be encountered within a few feet of the surface. In such cases difficulties with toxic materials in the soil may be expected due to the continued upward movement of water charged with saline materials under the influence of capillarity. However, the marked deterioration of such land can be prevented by sound drainage principles. Such soils, when adequately protected, are often outstandingly productive.

For a comprehensive treatise on the soils of the Ha-

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<sup>3</sup>This paragraph and the next one were prepared by Prof. H. A. Wadsworth, of the University of Hawaii.

waiian Islands, see "Handbook of Hawaiian Soils" published by the H.S.P.A. Experiment Station in 1935.

The reader interested in a detailed discussion of geographical features of these Islands is referred to Coulter's "Land Utilization in Hawaii," cited in a preceding footnote. Climatic variations are discussed by L. H. Daingerfield, of the U. S. Weather Bureau, in Thrum's Annual 1920, pages 43 to 48.



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Honolulu, Hawaii, U.S.A.  
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## Historical Outline of Agriculture In Hawaii

In the matter of land occupation the Hawaiian Islands have passed through a long history of development which may be divided into three distinct periods.

First, there was a very long period during which there was no human occupation of the land. A limited number of species of trees and smaller plants had by chance become established on these remotely isolated islands and multiplied to form a more or less dense forest cover wherever there was sufficient soil and moisture to support it. Of animal life there were several kinds of birds, a good many species of insects and lower forms, but no large beasts; the largest mammal was a small rat. Thus for untold thousands of years were these islands occupied, until the first human beings arrived.

The second period began with the arrival of these first humans, a small band of Polynesians, probably about 1500 or 1800 years ago. As they multiplied in numbers, they found it necessary to change the manner of occupation of the land, clearing much of the shore plain area for their cultivated crops, and changing the nature of the lowland forests somewhat by the introduction of additional plants of economic value, such as banana, coconut, breadfruit, etc. The animal life of the islands was materially changed by the introduction of pigs, dogs and chickens, some of which went wild, and by the depletion of the bird population as a result of the incessant hunting for them to obtain feathers for ceremonial capes and cloaks. In this second period the land occupation was definitely of an agricultural type, but with relatively few crops really cultivated (mainly taro and sweet potatoes) and no industrialization of agriculture. Because there was no winter to require the laying up of reserve provisions, no intercourse with the outside world to upset their economy, and no apparent



desire for greater diversity of food than the simple diet with which they had long been familiar, the Hawaiian people were able to maintain successfully for fifteen or twenty centuries their occupation of these islands and doubtless could have continued much longer if they had been left undisturbed.

The third period began in 1778 when Captain Cook opened the way for western civilization to enter and to change again the nature of the occupation of the land by using the arable areas much more extensively and intensively for commercial purposes rather than for simple subsistence.

### *Diversification*

This third period is one essentially of diversification. In the preceding period the land was required to yield only enough of a few staples to satisfy the simple wants of the people who occupied it, but now there began an era in which the wants and desires of the whole world influenced the uses to which the land was put.

This began with the desires of the crews of merchant and whaling ships which put in at the Hawaiian ports to replenish their dwindling stores of food. Since their tastes and desires were somewhat different from and more varied than those of the Hawaiians, there began to be felt an urge to diversify the agriculture of these islands. Taro from then on gradually declined from its position of predominance among cultivated crops, for it was not in great demand in the outside world, while certain other products and potential crops were much in demand.

From 1800 to about 1855 agriculture in the Hawaiian Islands was not only diversified; it was very miscellaneous, without much order or organization, for the economy of the preceding period was being swept aside by invading forces and the new economy which was soon to establish itself had not yet made itself clear. Many new plants and animals were introduced in an unorganized way by individual effort, without regard to potential harm which might follow; while many of these introductions proved to be useful, a few became more a nuisance than a benefit. Many crops were given more or less of a trial in a groping

effort to find those that would best fit the situation. Sugar cane, coffee, rice, cotton, silk, wheat, rubber, tobacco, vanilla, sisal hemp, several leguminous crops, avocado, banana, orange, beef cattle and poultry stand out as conspicuous among the scores which were given some attention as possibilities. Of some of these early experiments only scant records were kept, and of some none at all, so that our knowledge of many of them is comparatively meagre; of a few, such as sugar and coffee, the early record is fairly complete.

With the invention in 1851 of a centrifugal machine for separating sugar crystals from molasses,<sup>1</sup> sugar production received a great stimulus in Hawaii and within the next few years it emerged definitely as the leading industry.

From 1855 to 1882 the agriculture of these Islands was almost completely dominated by the sugar industry. Efforts and suggestions to foster the development of other large industries were given but scant encouragement, and Hawaii again, as in the long period of Polynesian occupation, became virtually a one-crop country, sugar cane having taken the place of taro in this preeminence.

Actually, of course, this predominance of the sugar industry did not cause the complete elimination of other crops. There were beef cattle ranches, and a small production of coffee, bananas and many other minor things. There was a significance in the persistence with which a few people continued to experiment with other crops and to lift their voices in favor of diversification, even though they did seem to be little more than voices "crying in the wilderness."

In the early 1880's there was a minor panic in the United States which caused a drop in the price of sugar, the injurious results of which in Hawaii were greatly accentuated by the almost complete dependence of everybody on the sugar industry.

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<sup>1</sup>The idea of a centrifugal machine for sugar was borrowed from the textile industry where it had been used for a number of years for drying fabrics. While there were some early efforts made in the 1840's to use the principle in the sugar industry, it did not affect Hawaii until 1851, when David M. Weston made a small centrifugal machine on Maui. The next year he made several larger machines. See N. Deerr, "Cane Sugar," p. 372; J. G. McIntosh, "Technology of Sugar," pp. 256-257.

To add to the distress of this situation there developed a fear lest the new beet sugar industry in California would grow to such large proportions as to ruin the Hawaiian producers. Some believed that the best protection would be the development of other agricultural industries upon which Hawaii could fall back if sugar should fail. The *Planters Monthly*, organ of the sugar industry, expressed itself editorially as being in favor of such a course, declaring on one occasion, for example, that "several months ago this journal urged the importance of turning attention to some other industries besides sugar. The present decline in the price of sugar is not temporary."<sup>2</sup> The policy of "sitting down with our hands folded," while the California beet industry "cuts our throat,"<sup>3</sup> was severely criticized. Several promising crops were mentioned as alternatives for sugar. As another means toward diversification Sanford Dole and others offered a plan for making land available to small farmers, a scheme which found favor with the *Planters Monthly* on the ground that it would enable Hawaii to "raise some of the things consumed here instead of importing them."<sup>4</sup>

It cannot be said, however, that this was the view of all. In spite of the current difficulties most of the leaders of the sugar industry remained strong in the belief that Hawaii's best policy was to continue "carrying all her eggs in one basket" and to watch the basket with the utmost care. They vigorously opposed suggestions made in those days of depression that agriculture should be diversified for the sake of economic safety, for they saw the difficulties of rival industries competing for the limited supplies of capital and labor, not to mention land and irrigation water. In the late 1880's recovery of prices and a brighter outlook seemed to have justified this policy, but not for long.

In the early 1890's, a more severe depression began in Hawaii, as a result of the McKinley Tariff Act of 1890, and was greatly accentuated by the American Panic of 1893. This seems to have marked the beginning of a new phase in Hawaii's industrial development, for the down swing of sugar prices again caused much economic trouble

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<sup>2</sup>Vol. III, p. 394, 1884.

<sup>3</sup>Vol. VI, p. 390, 1887.

<sup>4</sup>Vol. III, p. 437, 1884.

and those who urged diversification of agriculture began to have a better hearing. There was less opposition than formerly and more of the leaders of the sugar industry were sympathetic with that view and cooperated in efforts to develop new industries. In the *Planters Monthly*<sup>5</sup> one reads that "encouraging reports come in from the American colony at Wahiawa," where 53 homesteaders were trying to make a living by the production of fruits: oranges, bananas, pineapples, figs, olives, mangoes, peaches, etc. Again, one finds evidence of this interest in new crops in the list of the names of directors of a new company<sup>6</sup> organized for the production of coffee and tea in Kona: H. P. Baldwin, Chas. M. Cooke, G. N. Wilcox, and several other leaders of note.

The possibilities which were considered in the 1890's to be most promising for large development were coffee, pineapple, ramie fiber, and vegetable oils, especially coconut oil.<sup>7</sup> It is interesting to note that one of these, the pineapple, actually did become the basis of a major industry; coffee subsequently had a boom but not for long, while neither of the other two developed much at all.

### *Homesteading*

In 1895 there came a new stimulus to diversification when the newly established Republic passed a land act<sup>8</sup> making it possible for farmers to acquire small land holdings either by purchase or long<sup>9</sup> lease. A beginning at homesteading had been made in 1884 by King Kalakaua when he offered many small farm lots for sale,<sup>10</sup> two to twenty acres each. The conditions imposed by the King included occupation and cultivation of the land during a period of five years. Although 557 of the lots were "taken up," only 256 were actually deeded to the homesteaders,<sup>11</sup>

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<sup>5</sup>Vol. XX, p. 297, 1901.

<sup>6</sup>The Hawaiian Coffee and Tea Co. The *Planters Record*, Vol. X (1891) devotes ten pages (77-87) to a prospectus of this company.

<sup>7</sup>Thrum's *Annual* 1893, p. 105.

<sup>8</sup>Act 26, Session Laws of 1895.

<sup>9</sup>999 years.

<sup>10</sup>Session Laws 1884, p. 86.

<sup>11</sup>Hobbs, "Hawaii—Pageant of the Soil," p. 105 (Stanford Press, 1935).



the rest remaining the property of the government because of failure of those who took them up to fulfill their contracts. Those who did obtain their farms do not seem to have done much with them, for their farming operations were not sufficiently successful to attract others to follow their lead.

President Dole's effort was more successful, perhaps because popular sentiment had meanwhile undergone some change and had become more favorable to diversification. Some 521 small land holdings were acquired under the 1895 Act, among them being some in the Wahiawa (Oahu) region where the pineapple industry had its birth. When the Republic became the Territory of Hawaii a few years later the provisions of that Act were continued in force by the Organic Act.

In spite of the fact that homesteading laws in Hawaii have certain weaknesses and have attracted many speculators, nevertheless they have exerted a definite influence toward the diversification of agriculture. Figures compiled in 1928<sup>12</sup> show that by that time over 4000 lots had been taken up. Many of them, it is true, were used for producing sugar cane, but a great many were devoted to other crops in a groping effort to be free from the regimentation of the sugar industry.<sup>13</sup>

### *Hawaii Experiment Station*

At the turn of the century, annexation to the United States introduced another influence toward agricultural diversification: the establishment of an experiment station which was to be devoted principally to the objective of developing new crops for Hawaii. When Hawaii became a part of the United States the federal Department of

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<sup>12</sup>Report of the Governor of Hawaii, 1928.

<sup>13</sup>Homesteading in Hawaii has led to the development of a considerable amount of small farming, the chief incentive for which has been this desire on the part of some individuals to free themselves from the regimentation of big business. The reader who is interested in knowing something of the situation in which the average small farmer or homesteader lives and works is referred to F. E. Armstrong's "A Survey of Small Farming in Hawaii," published by the University of Hawaii in 1937 as Research Publication No. 14; also, to D. L. Crawford's "Paradox in Hawaii," Chapter VII (Stratford, 1933).

Agriculture noted the excessive preeminence of the sugar industry here and, mindful of the unfortunate results of over-specialization in the cotton belt of the southern states, advocated very strongly the diversification of agriculture in these Islands. In accordance with this attitude an agricultural experiment station was established by the federal government in 1901, on the outskirts of Honolulu, which devoted itself to the investigation of potential new crops and industries for this newly annexed Territory. While a large number of possibilities were explored during the ensuing years, chief emphasis was placed on a few which seemed to offer the best promise, notably tobacco, rice, rubber and starch;<sup>14</sup> also, several fruits received a good deal of attention, especially the orange, avocado, pineapple, mango, banana and papaya; and several vegetable crops.

The work of this Station undoubtedly contributed materially to the successful establishment of the pineapple industry, for, although pineapple production was definitely on the way to becoming an industry before the Station was able to give it any material assistance, it was the discovery of the iron sulfate treatment that enabled the new industry to occupy large land areas theretofore unavailable because of too much manganese in the soil.<sup>15</sup>

A new force was introduced into the situation in 1907 by the establishment of a territorial institution of higher learning,<sup>16</sup> which in addition to offering agricultural instruction also conducted some researches in the field of general agriculture. Such federal aid as it received was available only for instructional functions, however, and therefore its agricultural research work had to depend upon territorial appropriations for its support. This disparity with the mainland states was remedied some years later, in 1928, by an act of Congress making available to

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<sup>14</sup>For a summary statement of these efforts refer in this volume to "Tobacco," "Rubber," and "Starch" and the other items mentioned here.

<sup>15</sup>The pineapple industry had not at that time established its own experiment station (see "Pineapple").

<sup>16</sup>This was established by the 1907 Legislature as the College of Agriculture and Mechanic Arts, with federal aid from the "land grant college" act of Congress; the name was changed in 1909 to "College of Hawaii," and in 1919 to "University of Hawaii."

Hawaii a share of all the federal aid funds<sup>17</sup> appropriated for agricultural research in the land grant colleges. At the same time an agreement between the U. S. Department of Agriculture and the University of Hawaii was effected for the amalgamation of the federally controlled Hawaii Experiment Station and the University's research station. During a transition period of several years<sup>18</sup> it was provided that the fusion station should be controlled jointly by the Territory and the U. S. Department of Agriculture, and thereafter by the Territory alone, with the same co-operative relations with the Department of Agriculture as obtain in the states.

Thus, there finally emerged here an agricultural experiment station with financial support enough to make it an important factor in the diversification of industry in these Islands, and capable of meeting the crisis which was presented by the recent depression.

### *Cooperative Extension Service*

Before considering this depression and its effects on Hawaii's agriculture, however, it is necessary that we turn our attention for a moment to the work of that governmental agency which is widely known as the "Extension Service."

Extension service began early in the current century as an effort on the part of several state universities and agricultural colleges to extend themselves into rural communities a little more effectively than they had been do-

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<sup>17</sup>The Hatch Act (1887) appropriated \$15,000 per year to each land grant college for agricultural research; the Adams Act (1906) added another \$15,000 by several annual increments; the Purnell Act (1925) provided an additional \$60,000 to each state, also, by annual increments, the first year \$20,000 being given and each year thereafter an increase of \$10,000 until the maximum of \$60,000 had been reached. Hawaii's participation in these funds was put on the same basis by an act of 1928, beginning with \$15,000 in 1929, then increasing to \$20,000 the next year and further increasing by \$2000 more each successive year for five years until the annual total became \$30,000 in 1935; then the increase was to be to \$50,000 in 1936 and annual increments of \$10,000 each thereafter, until in 1940 the total amount available from the three acts would be \$90,000 per year. Meanwhile, the support which had been given by the U. S. Department of Agriculture to its station here (about \$42,000 per year) was to be reduced each successive year by the same amount as provided by the Hatch, Adams and Purnell Acts.

<sup>18</sup>This was the time required (1929 to 1937) for the annual increments to equalize the \$42,000 theretofore provided by the Department of Agriculture without reference to the above mentioned federal aid acts.

ing through the medium of bulletins and leaflets. These scattered efforts led to the passage of an act by the United States Congress in 1914, the Smith-Lever Act, providing funds for a nation-wide system of agricultural advisers, or county agents, and to operate in connection with not only the state "land grant" colleges of agriculture but also the U. S. Department of Agriculture; because of this dual arrangement the new program is called the "Cooperative Extension Service in Agriculture and Home Economics."

Hawaii's participation in the provisions of this Smith-Lever Act prior to 1928 was indirect and far from complete. The Hawaii Experiment Station, which then was wholly under federal control, was given a small fund annually to cover the expense not of a *system* of county agents as in the states but only of one agricultural agent in one county (Hawaii) and one home demonstration agent in another county (Honolulu).

In 1917 the World War obstructed the normal movement of commercial shipping to Hawaii and threatened her with a possible food shortage. The situation was met by the establishment of a territorial system of county agents who assisted farmers in the emergency production of food crops. The system was discontinued, however, soon after the war ended.

In 1919 the University undertook to develop, without federal aid, a program of extension service which, though very limited in scope at first, in a few years grew to considerable proportions and became the basis of a successful appeal to Congress in 1927 for inclusion of Hawaii in the provisions of the Smith-Lever Act.

This took effect in 1928 and resulted in a large expansion of the extension service,<sup>19</sup> with farm advisers and home demonstration agents in each county and several technical specialists in the Honolulu office at the University to serve the entire Territory. While this service was directed toward the general objective of helping all rural folk in their efforts to make a living, its most useful function has been the building up of our minor farm

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<sup>19</sup>The federal aid appropriation amounted to something over \$50,000, with an additional \$20,000 of territorial money required as "offset." This has subsequently been increased to a total (both federal and territorial) of nearly \$140,000 per year.



industries and the fostering of new industries, all aimed at the greater diversification of Hawaii's agriculture.

### *Large Movement Now Under Way*

The recent depression has served as a powerful stimulus to Hawaii to diversify her agriculture. Fortunately, her experiment station and extension service had been developed to the point where they could assist materially in reacting to that stimulus. It was equally fortunate that there had been a definite trend toward diversification since the 1890's, for even though it was not a strong trend and had elicited only lukewarm support from most of our industrial leaders, nevertheless the ground had been prepared and there was need only for some major stimulus to furnish an impulse toward important developments.

The impulse came first from the pineapple industry. The depression had by 1931 so seriously reduced the purchasing power of the American people that the normal demand for canned pineapple declined to a very low point and left the producers here with an enormous surplus of goods on hand. Being highly organized, the industry was able effectively to curtail its production to fit the situation, but that caused large land areas to be thrown out of use and immediately a search began for substitute crops to keep the lands busy.

Shortly thereafter the sugar industry of the entire world found itself in a similar difficulty, but since Hawaii was only a small factor in the situation it was not possible to solve the problem as simply as the pineapple industry was doing. After two years of futile effort by the industry itself to obtain united action among all sugar producers throughout the world, the United States government devised a plan for itself, drastically restricting imports from foreign countries and placing all her own producers on a quota basis. For Hawaii this meant a curtailment of production and, as a result, considerable areas of land were made idle and the owners began to seek other crops to keep them occupied.

The problem faced by these two major industries in Hawaii, and by the Territory as a whole, was not one that could be solved quickly, for new industries cannot be established in a day. Fortunately, however, a minor feature

of the sugar quota plan provided a means of working out a solution for the problem: a small part of the money to be collected by the federal government as a processing tax on sugar was to be set aside for use in developing other agricultural industries to take up the slack in the sugar industry. For Hawaii this amounted to about \$500,000, and was to be spent in accordance with the advice of a special committee created by the federal government, all local men except one representative of the U. S. Department of Agriculture. This committee devised a plan for (1) assisting several minor industries to meet their most serious difficulties and thus be able to expand as much as they might be capable of doing; (2) devising, if possible, new processes for marketing present crops (such as taro, etc.); and (3) exploring the field for crops new to Hawaii which might become the basis of important industries. The major portion of this work was assigned to the Hawaii Experiment Station and the Extension Service and got under way in 1935 and 1936.

Although some very important results from this work are beginning already to appear, the most significant feature in the present situation is the cooperative interest being shown by the leaders of both major industries.<sup>20</sup> Even though the present crisis has passed for both, there is the general realization, made still more vivid by the shipping strike of 1936-1937, that Hawaii's best economic security lies in a reasonably wide diversity of her agricultural industries, rather than in a concentration of all effort and resources in two major industries.

A movement of major importance to the Territory is under way, out of which there will probably emerge in due course of time one or more new industries of large economic value to Hawaii. Another result should be an increased production of many of the food commodities which are required for local consumption.

### *Study the Past*

At the present stage in this movement toward diversi-

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<sup>20</sup>See, for example, the report of the "Committee on Diversified Agriculture" of the Hawaiian Sugar Planters' Association. In 1935 the H.S.P.A. appointed a committee to study possibilities for effecting greater diversification of industry in Hawaii. The first report of this committee was published by the H.S.P.A. in October, 1936.

fication, when a wide search is being made for those crops and industries which hold the best promise for Hawaii's future, it is well to examine carefully the records of past efforts along the same line. Many kinds of plants and animals have been the object of experimentation here during the past 150 years, some of them having seemed for a time to be so promising that considerable sums of money were invested by interested people in the expectation of developing remunerative industries on them. Examples are rubber, starch, tobacco, banana, coconut, sisal, cotton, etc.

The record of the past reveals, also, that some industries flourished for a time but eventually waned when the commodity on which they were based passed out of vogue or was supplanted by something better or cheaper, or when the natural supply became exhausted as in the case of the sandalwood. Examples of commodities which were supplanted are the pulu (tree fern silk), exported to California for upholstery uses until California cotton took its place; wheat, potatoes and rice shipped to California until production there proved to be cheaper; pepeiau akua, a mushroom growth which was the basis of a flourishing trade for several years; sisal hemp, and several others might be added.

### *The Present and The Future*

Out of the efforts of the past decades two industries of major proportions are now established and thriving well, each yielding economic returns to Hawaii annually of many millions of dollars; also, a goodly number of minor industries are yielding their thousands and hundreds of thousands of dollars of returns and even, in a few instances, a million or more.<sup>21</sup> These are worthy of careful study to discover latent possibilities in them for further expansion.

A summary list of these is as follows:

Over \$10,000,000 per year:

Sugar cane and its products

Pineapple—canned, fresh and by-products

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<sup>21</sup>In appraising the value of these industries local consumption as well as exports is taken into account.

Over or near \$1,000,000 per year:

- Beef cattle
- Dairy cattle
- Poultry (including eggs)
- Coffee
- Swine
- Taro

Over or near \$100,000 per year:

- Rice
- Banana
- Papaya
- Potato
- Flowers
- Cabbage
- Coconut
- Avocado

Over or near \$50,000 per year:

- Tomato
- Watermelon
- Honey and beeswax
- Sheep (wool)
- Macadamia nut
- Guava
- Truck crops (other than those specifically mentioned)

Considerably under \$50,000 per year:

- Citrus fruits
- Sweet potato
- Onion
- Mango
- Strawberry
- Poha
- Asparagus
- Cotton
- Ohelo

Livestock feeds have not been included in the above list because their value is expressed in the beef, pork, dairy and poultry products into which they go. The most valuable of the feeds are pasture grasses, pigeon pea, algaroba, molasses, pineapple bran, etc.

As for the future, one can but examine current trends

and point out certain potential possibilities which seem to offer more promise than others for profitable exploitation. There are two important trends which should be kept in mind in looking to the future:

I—The development of one or several new industries for the large markets outside of Hawaii; certainly the following should be given consideration:

Fiber crops:

- Banana
- Bowstring hemp
- Pineapple
- Ramie
- Silk
- Sunn hemp

Fruits and nuts:

- Banana
- Cashew nut
- Guava
- Litchi
- Macadamia nut
- Mango
- Papaya
- Passion fruits

Starch crops:

- Canna
- Cassava
- Sweet potato
- Taro

Vegetables:

- Asparagus
- Pigeon pea
- Potato
- Tomato

Miscellaneous:

- Soy bean

Among these twenty-odd there are a few which seem to offer especially good possibilities for development on a large scale:

1. TARO—Hawaii is both accustomed and adapted to the production of taro; as for marketing, it should not be



very difficult to introduce taro flour and related products in the American market and thus develop an adequate outlet for all that Hawaii could possibly produce.

2. **FRUIT BLENDS**—Instead of trying to introduce one or several new fruits to the American market, with all the expensive advertising and educational effort which that would require, it is suggested that fruits and fruit juices be combined and offered to the mainland under an already familiar label such as "Hawaiian" or "Tropical," both of which carry definite sales appeal without any preliminary campaign of education. The proposed plan should be considered under two subheads:

- (a) *Hawaiian Fruit Cup*—Since a process is now known for making papaya hold its shape when canned, it is suggested that a combination of diced papaya, mango and pineapple with whole litchi (seeded), be canned under a trade name such as "Hawaiian Fruit Cup."
- (b) *Tropical Punch*—The juice of several fruits, as papaya, passion fruit and perhaps others (guava, pineapple, etc.), could be blended to make a delicious base for fountain drinks, cocktails and other uses.

3. **WINTER PRODUCE**—The mainland market is relatively very short of certain standard commodities during the winter months and offers a special inducement to Hawaii to develop a seasonal business on a large scale. The best opportunities for this are in the following commodities:

- (a) *Potato*—So-called "new" potatoes are very scarce in the mainland markets in the winter and early spring months and Hawaii already has begun to take advantage of the situation. Several hundred acres of this crop are being grown and a profitable industry is developing. It could develop into very large dimensions, especially in combination with such a crop as *Soy Beans*, for which there is an almost unlimited market now.
- (b) *Asparagus*—This is another crop which offers great promise for development into a large and profitable seasonal industry, but unlike the potato

it would occupy its land throughout the year and could not be alternated with another crop.

- (c) *Tomato*—If some means can be found to secure a modification of the fruitfly quarantine, a large industry could be developed in the shipping of winter tomatoes to the mainland.

The chief difficulty in all three of these winter produce commodities is that they would be shipped in the fresh state and would, therefore, involve all the risk that lies in the sending of perishables to markets 2000 miles distant. When it is considered, however, that Mexico and the Pacific Coast states ship thousands of carloads of fresh fruit 2000 to 3000 miles to reach the large markets, Hawaii should encounter no insuperable obstacle in the matter of distance. It is believed, moreover, that there are exceptionally attractive possibilities in this seasonal trade.

II—The production of many kinds of fruits, vegetables and other crops on a comparatively small scale, chiefly for consumption within Hawaii. In this category the following (arranged alphabetically) seem to offer good promise:

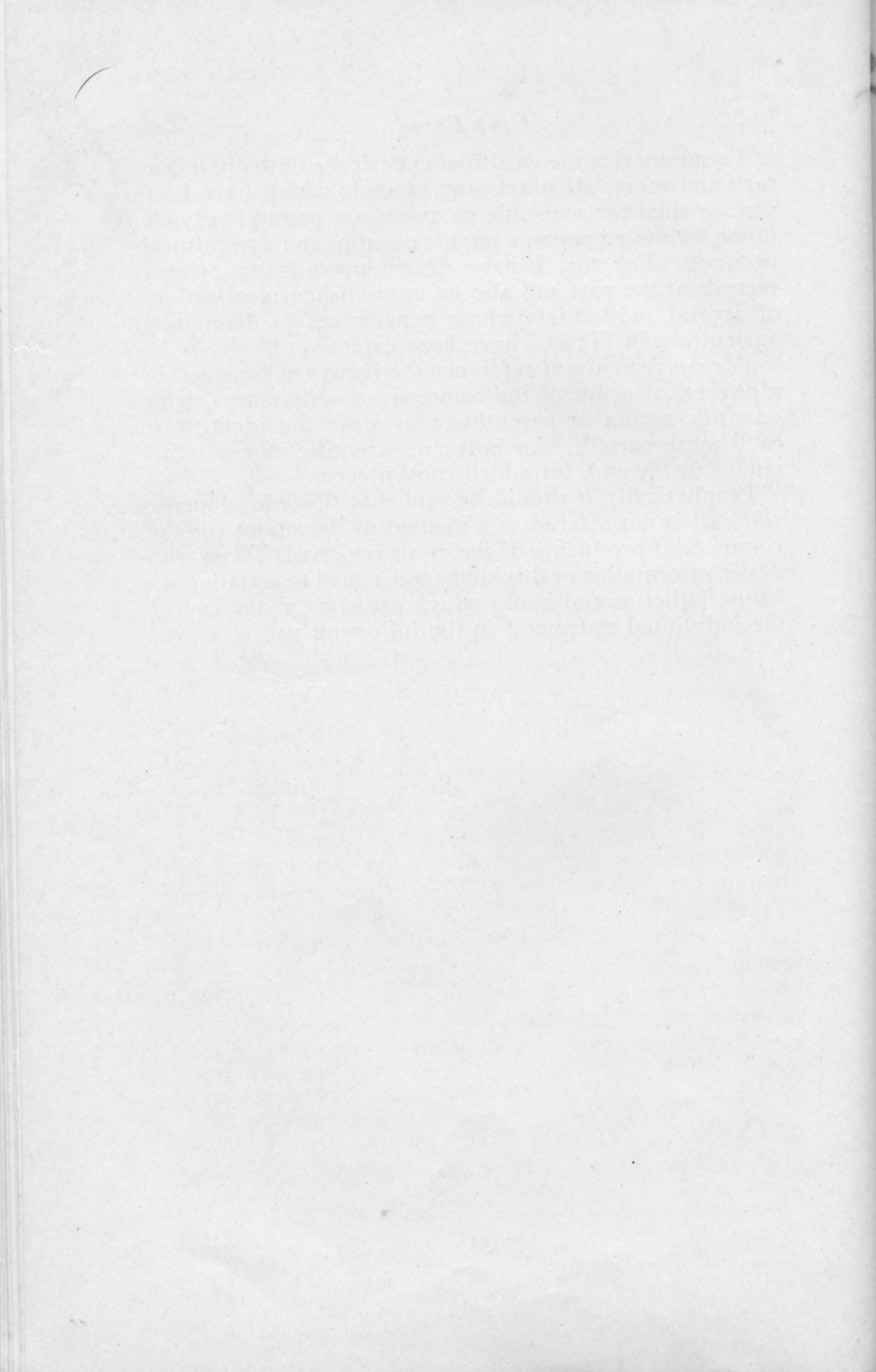
Avocado  
Banana  
Beans  
Breadfruit  
Cabbage  
Cauliflower  
Citrus fruits  
Coconut  
Dairy products  
Fig  
Mango  
Melons  
Onion  
Potato  
Poultry  
Strawberry  
Taro  
Tomato  
Truck crops

### *Crop Parade*

To summarize the wealth of experience of the past century and more, all plants and animals which have been used or tried for economic purposes, are passed in review in the following pages, a parade of crops and agricultural products. For this I have drawn upon many printed records of the past and also on unpublished recollections of several individuals whose experiences in diversified agriculture in Hawaii have been extensive.

For convenience of reference the items are arranged in alphabetical order of the common or trade names, with scientific names in parentheses to make the identity of each more certain. An index of scientific names is included at the end, for added convenience.

Emphatically it should be said that this encyclopedic roll call is not offered as a manual of directions for the commercial producing of the crops reviewed. Those who desire information of this kind are directed to certain published bulletins and books which are cited at the end of the individual statements in the following pages.



# HAWAII'S CROP PARADE

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**ABACA** See "Manila Hemp."

**ACACIA** See "Koa," also "Tan-bark."

**AKALA** The akala is a native species of raspberry (*Rubus macraei*)<sup>1</sup> which flourishes in certain upland regions of Hawaii, notably in the Kona, Kau and Hamakua districts of the Big Island at elevations of 5000 to 7000 feet. It grows wild in the forest areas, the bushes being perennial and attaining a height of four to ten feet.

The fruit is typically about an inch in diameter and handsome in appearance, resembling a large dewberry or blackcap raspberry. Unfortunately, however, the flavor is tart and somewhat bitter—possibly too much so for successful marketing.

Since 1929 the Hawaii Experiment Station has been trying to modify this native akala berry by crossing it with other species of *Rubus* so that the flavor would be better. Thus far these efforts have been only partially successful, as some improvement can be noted but not enough to warrant commercial exploitation. Some are enthusiastic about this fruit, however, and believe that it might become an important item in Hawaiian horticulture.

Although naturally a denizen of the forest, the akala responds readily to cultivation practices and could be produced commercially at higher elevations. Perhaps a strain might be developed by selective breeding which would do well nearer sea level, as in the coffee belt of Kona.

Ref.—Haw. Exp. Sta. Report 1929:19; 1930:26; 1931:23; 1933:10.

**ALCOHOL** With the advent of the white man into Hawaii there came the art of making alcohol. This art,

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<sup>1</sup>Another, less common, species which also is called akala, is *Rubus hawaiiensis*.



however, was not used commercially on a very extensive scale; small industries developed in the making of wine from grapes and other intoxicants from various starchy or sugary substances (see "wine," "ti," "molasses," etc.). With thousands of tons of molasses coming out of the sugar mills as a by-product, it is remarkable that the manufacture of alcohol was not more extensively developed in the nineteenth century.

Interest in the making of industrial alcohol became active early in the current century. H.S.P.A. scientists turned their attention to the possibilities of making denatured alcohol as a substitute for gasoline to be used as a fuel in automobiles, engines, and ships. S. S. Peck and Noel Deerr reported in 1909<sup>2</sup> that Hawaiian molasses was worth about 8.3 cents per gallon when figured in terms of the alcohol and other products capable of being made from it. In addition to the alcohol distilled out, it was pointed out that the residue contains brewer's yeast, useful as a feed for livestock, and some potash, useful as a fertilizer; also, carbonic acid gas (carbon dioxide) is recoverable during the process of alcohol manufacture.

Tests were made to ascertain the value of alcohol in comparison with gasoline, with results that were somewhat encouraging but not sufficiently so to cause the sugar industry to develop the manufacture of this fuel on a large scale. One plantation on Maui undertook to make it in moderately large quantities and used it experimentally in tractors, trucks and other internal combustion engines with good results. The general attitude, however, was not favorable to it, chiefly because of the higher cost compared with gasoline. One expert expressed the attitude of many when he declared that alcohol is "hopelessly handicapped where petroleum oil is abundant and labor costly."<sup>3</sup>

Interest continues, nevertheless, in the manufacture of this fuel from molasses because of its potential importance in time of emergency when normal imports of gasoline and petroleum fuels might be interrupted.

Meanwhile, attention turned some twenty years ago to

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<sup>2</sup>Agricultural Bulletin 28, H.S.P.A. Experiment Station.

<sup>3</sup>Planters Record, Vol. XI, p. 108, 1914.

pineapple juice as a possible source of industrial alcohol. One large pineapple cannery in Honolulu uses its excess juice and waste in this way, marketing considerable quantities of denatured and absolute alcohol. The carbon dioxide evolved in the process of fermentation is sold to a neighboring firm which compresses it in steel tanks and sells it for use in the making of carbonated beverages and other purposes.

Ref.—Out of many references in the Planters Record, the following are of special interest: Vol. I, 197; IX, 580; X, 78; XI, 107; XIV, 144; XVI, 165, 439; XVIII, 379; XX, 23; XXI, 345; XXII, 172; XXIII, 38-52; also, Agr. Bul. (H.S.P.A.) No. 28 (1909).

**ALFALFA** Alfalfa (*Medicago sativa*) is an excellent forage and hay crop for livestock, especially for dairy cattle, but is not extensively used in Hawaii because of the relatively high cost of producing it. Weed control, especially during the first year when a field is being established, is very expensive and troublesome, causing most dairymen to plant other kinds of feed crops which are better suited to Hawaiian conditions. Once established, an alfalfa field produces about ten crops per year for six to ten years before replanting becomes necessary, the annual production being 40 to 60 or more tons of green fodder, or 10 to 15 tons of hay. Except in some dry localities, it is almost impossible to cure alfalfa hay properly, and consequently it is nearly always used green, in combination with other green feeds; too much green alfalfa may have a laxative effect on dairy cattle.

Production of alfalfa in Hawaii is not extensive; only a few dairymen cultivate it, and the total of their plantings is probably not over 100 acres.

A spreading pasture type of alfalfa (*Medicago falcata*) has been introduced from Wisconsin during the past few years and is doing well in the cooler upland areas. This type is not suited to hay making, but may be an important feature in pasture improvement.<sup>4</sup>

Ref.—U. H. Agr. Dept. Annual Reports 1918:2; 1919:5; 1920:7; 1921:6; 1922:6; 1923:6; 1924:6; 1925:7, 33; 1926:40; 1927:30; 1928:14, 35; 1929:30; 1936:19; Haw. For. Agr. 1914:52, 77, 106, 171, 217, 252 (series of articles by F. G. Krauss).

<sup>4</sup>Haw. Exp. Sta. Ann. Rep. 1936: 11, 19.

**ALGAROBIA** The algaroba (*Prosopis chilensis*), introduced a little more than a century ago (1828)<sup>5</sup> has become one of the most valuable of our forest trees in the lowland areas. It is commonly said to be the same as the mesquite of southwestern United States but that is not true, for there are important botanical differences between them. It is more probably true that our algaroba came from Peru, for there is in that section of South America a *Prosopis* species which seems to be identical with ours. The first seeds were brought here by Father Bachelot, a Catholic missionary, and the original (Hawaiian) tree was growing until a few years ago in the downtown portion of Honolulu.

From this parent tree there are millions of offspring, some growing even in the remotest sections of the Territory, so thorough and widespread has been the dissemination—largely natural. Practically all the drier areas on the leeward side of the islands have been occupied by this immigrant tree which forms dense, sometimes almost impenetrable, forests extending from the ocean shore to several miles inland and to a hundred or two hundred feet elevation above sea level. Fully 90,000 acres of semi-arid shore-plain lands not exposed to the salt spray of the ocean are now covered by it.

The algaroba is a leguminous tree and produces pods which have a very considerable value as a feed for livestock. Many tons of the pods are gathered annually as they fall to the ground and are used for feeding horses, cattle and swine. But to every ton gathered and used in this way many tons are picked up by grazing livestock as a supplement to grasses and other forage plants.

Estimates of the yield of algaroba pods indicate that in some localities it may be as high as 4000 pounds per acre per year while in others it may not be more than 1000 pounds. Taking 2000 pounds as a conservative average,<sup>6</sup> and allowing a value of about \$20.00 per ton,<sup>7</sup> we find that

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<sup>5</sup>Haw. For. Agr. 1916:330-333 (C. S. Judd).

<sup>6</sup>Director E. V. Wilcox of the Hawaii Experiment Station estimated in 1913 (Press Bul. 39, p. 3) that the yield of algaroba pods varies from two to fourteen tons per acre. This is probably excessive.

<sup>7</sup>The feeding value is considered about equal to that of barley, which averages about \$40.00 per ton.

this species of tree is worth nearly \$2,000,000 per year to the Territory for its yield of livestock feed. In 1912 the actual sales of this commodity for feed purposes amounted to over \$750,000. The volume of sales has not continued in this amount to the present, but the value of the feed is no less real even if it is not recorded in commercial transactions.

The pods are not the only valuable feature of the algaroba. The flowers yield excellent honey and the wood is good both for fuel and for fence posts.

The total honey crop of the Territory is worth about \$75,000 per year, this being a rough average of the past ten years. It is a conservative estimate when we say that 75 percent of the total crop is gathered from the flowers of the algaroba trees. So far as market value is concerned, probably 90 percent comes from algaroba, for honey derived from most other sources here is dark and less desirable.

The wood of the algaroba is very hard, when dry, and makes excellent fuel, better by test than oak and hickory.<sup>8</sup> How much is burned as fuel wood is impossible even to guess, but the amount must be very large. Also, as charcoal it enters extensively into consumption; an estimate by F. G. Krauss places the amount of charcoal consumed at about 100,000 bags, worth about \$100,000 per year.

Algaroba makes good fence posts after being soaked in salt water. There is a boring beetle which quickly reduces the sapwood of dead branches and logs of this tree to dust if they are not impregnated with sea water, but after post material has been allowed to lie a few months in salt water it becomes immune to the attacks of the beetle and makes excellent fence posts which withstand decay for several years. Probably over \$10,000 worth of such posts are used in a typical year.

Ref.—Thrum's Annual 1913:148 (E. V. Wilcox); Haw. Exp. Sta. Reports 1914:19; 1916:7; 1919:37; 1921:20; Press Bul. 26.

**ALLIGATOR PEAR** See "Avocado."

**ALLSPICE** In the H.S.P.A. forestry station grounds in Manoa Valley (Honolulu) are several good specimens

<sup>8</sup>See C. S. Judd, in Haw. For. Agr., Vol. 18, No. 10, p. 218, October, 1921.

of the allspice tree (*Pimenta officinalis*), the species from which the allspice of commerce is derived. While it may offer some possibilities for exploitation in Hawaii, the experimental plantings have not yet proven themselves.

**ANGLETON GRASS** Angleton Grass (*Andropogon annulatus*) is a very promising range grass which is still on trial in the experimental grounds.

Ref.—Haw. Exp. Sta. Bul. 65:4, 1933.

**APICULTURE** See “Bees.”

**APPLE** A few trees of this temperate zone fruit (*Pyrus Malus*) are to be found at elevations above 4000 feet. Fruits of good appearance are occasionally exhibited at county fairs, but it cannot be said that there are attractive commercial possibilities in apple production in Hawaii. A recent crop survey (1936) indicates scattered plantings totalling about 4 acres in the uplands of Maui.

**APRICOT** The apricot (*Prunus Armeniaca*) like other temperate zone fruit trees, may be grown successfully in the higher areas of the Islands, at elevations above 3500 feet, and one may find a few trees here and there bearing fruit of good quality. It cannot be claimed, however, that the apricot offers any commercial possibilities of interest in these Islands.

**ARROWHEAD** Arrowhead (*Sagittaria sagittaeifolia*) is an aquatic plant, the corms of which are used as food both by Chinese and Japanese. Originally introduced into Hawaii by Oriental gardeners, this plant has escaped from cultivation and now grows wild in swamps. The leaves are shaped like an arrowhead, hence the name.

The corms are small, weighing an ounce or less, somewhat yellowish inside and of a consistency resembling that of the sweet potato.

See also “Truck Crops.”

**ARROW ROOT** An old advertising poster, yellowed with age, reposing for many years among the Judd papers recently opened for study, announces that “The Drug Store of the Undersigned (G. P. Judd), corner of Fort and Merchant Streets” is prepared to furnish “Sandwich Island Arrow Root” in large or small quantities.



This arrow root was a native starch,<sup>9</sup> known as pia, and was made from the roots of a tropical plant (*Tacca pinnatifida*) which at one time grew wild in certain localities. It was used to a limited extent by the early people of Hawaii, but efforts to make it a cultivated crop about 1840 were unprofitable, for there seemed to be relatively little, if any, gain in profit from the cultivated crop as compared with the wild plant.

A market in California was developed for this product during the gold rush days; in 1850 there were some 16,000 pounds of arrow root shipped out. The Royal Hawaiian Agricultural Society, through various members and committees, sought to foster this industry into something larger, one report, for example, declaring that "some hundreds of tons per annum might be manufactured at a cost not to exceed 4 cents."<sup>10</sup>

In spite of much urging, however, there never developed much of an industry in arrowroot and it remains today an article which could be exploited with profit, but is not.

There is some interest in this crop at the present time. Small quantities of the starch are made by Hawaiians in Kona by the ancient methods and the demand for it is such that as much as \$1.00 per pound is sometimes paid for the product. It is believed to have some special values both for medicinal uses (in cases of dysentery) and for cosmetic uses, as well. The Hawaii Experiment Station is growing the plant on its Kona grounds with a view to enlarging the commercial plantings and perhaps reviving at last this ancient industry.

Arrowroot starch made from another plant (*Maranta arundinacea*)<sup>11</sup> has been in more or less common use in Europe and to some extent in America, also, for a long time. Sold in small packages, at about \$1.00 per pound, it is in limited demand for use by invalids because of its ready digestibility. American imports of this starch are small, usually only a few hundred tons per year. This

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<sup>9</sup>For a good description of the process by which arrow root was made in the early days, see Trans. Royal Haw'n. Agr. Soc. Vol. II, No. 2, pp. 133-4 (1854).

<sup>10</sup>B. Pitman, in Trans. Royal Haw'n. Agr. Soc. Vol. I, No. 2, p. 51 (1851).

<sup>11</sup>Good culture directions for the growing of this plant are given in Planters Monthly XII, p. 163 (1903).

plant is cultivated here to a limited extent by Oriental gardeners for its fleshy root, which when young may be cooked to make a delicious food, somewhat resembling a sweet potato. The older roots are good only as a source of starch, and there is a very small industry in the making of this at the present time. This starch is much like the other arrowroot made from *Tacca pinnatifida* and is sometimes confused with it.

Both of these kinds of arrowroot starch offer limited possibilities for exploitation in Hawaii. The demand now existing here and on the mainland might become greater if the unit price were lowered, which could easily be done if production methods were modernized and large plantings developed. At best, however, the industry would probably never be very large, for neither of these plants offers as good prospects for starch manufacture as does canna or the sweet potato.

**ARTICHOKE** The artichoke (*Cynara scolymus*) is a perennial thistle plant which thrives best in cool, foggy areas. Although it is occasionally grown in Hawaii it does not seem to be well adapted to climatic conditions here and therefore does not offer much promise as a vegetable crop of importance. The edible portion is the immature flower, the bracts enclosing it being somewhat succulent and useful for salad purposes when cooked.

See, also, "Jerusalem Artichoke."

**ASPARAGUS** Asparagus (*Asparagus officinalis altilis*) is a perennial plant which thrives well under Hawaiian conditions. The new, tender, fleshy stems as they first emerge from the ground are so much prized as a food that during the winter months when this product is very scarce it may command prices as high as 75 cents and even \$1.00 per pound, in the large cities of the mainland.

Efforts to establish asparagus growing as an industry in these Islands have been sporadic and thus far have not brought any large results. In 1889 Allan Herbert made an experimental planting of this crop in Kalihi valley, obtaining roots from California. The results were excellent and he reported a realization of about \$1500 from one acre (the extent of his planting).<sup>12</sup> A considerable interest

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<sup>12</sup>Planters Monthly VIII, 483-484, 1889.

was aroused by this experiment and he offered to sell roots to others who wished to go into the production of this crop. Again, in 1901, there was a brief interest in asparagus growing, but it did not develop into anything of importance.<sup>13</sup>

During the past thirty years there have been several small commercial plantings, none of which were successful except one in the Pupukea district of Oahu where for the past five years one grower has been operating on an experimental scale; he is now cultivating something over 10 acres of this crop and has been successful in marketing his product on the mainland<sup>14</sup> at very attractive prices. This doubtless will lead to an expansion of the planting, for in the winter and early spring months fresh asparagus tips are scarce and expensive in the mainland markets and there is an excellent opportunity for Hawaiian producers to fill the demand.

Hawaii consumes a considerable quantity of asparagus, but mostly in the canned form. It is not probable that the local fresh product will be able to displace this, for the canned product meets certain needs which the fresh material does not fully satisfy.

Asparagus plants grow continuously for a number of years, producing few if any marketable tips the first year and increasing amounts in the second and third years when there should be about 4000 pounds per acre.

For detailed information on culture, harvesting and other features, consult the University's bulletin on truck crops.<sup>15</sup>

**AUSTRALIAN BLUEGRASS** Australian bluegrass (*Andropogon sericeus*) is a hardy and very desirable grass for dry lands at low elevations, and is well established on Maui.

Ref.—Haw. Exp. Sta. Bul. 65:7, 1933.

**AVOCADO** The avocado (*Persea gratissima*) is considered by many to be the potential basis of a very large

<sup>13</sup>Planters Monthly XX, 125, 1901.

<sup>14</sup>Until recently asparagus tips were included in the list of commodities quarantined by the U. S. Department of Agriculture because of the fruitfly and melon fly, but by the efforts of Mr. Farrar, the Pupukea grower mentioned above, it was proven to be immune to attack and the quarantine was lifted.

<sup>15</sup>Agr. Ext. Bul. 16, p. 52-59, 1932.

industry in Hawaii. The popular demand for this salad fruit has increased greatly throughout the United States and in other countries as well during the past quarter century and the outlook for the future seems to be for a further expansion of the market for it. How much of this market might be captured by Hawaii depends chiefly on two factors: the fruitfly quarantine and the competition from mainland producing areas, notably California and Florida.

Hawaii might have become a leading production center for the American market if the Mediterranean Fruitfly had not come into the situation just as popular interest was beginning to show itself in the possibility of developing an avocado industry here. Conditions of soil and climate were known to be almost ideal in these Islands, for the avocado thrives best in a subtropical climate which is wholly free from frost. It was no mere theory that this fruit would do well in Hawaii, but a known fact, for it had been widely grown as a backyard tree ever since early in the nineteenth century after its first introduction by Don Marin, the Spaniard to whom we owe our thanks for having brought hither many valuable fruit trees and other economic plants.

The first large introduction of many avocado varieties was in 1853<sup>16</sup> when the United States warship *Portsmouth* left a considerable number of seedling trees at Lahaina. These and numerous other importations resulted in there being a great many bearing trees of dozens and scores of different varieties by the end of the century, when Annexation stimulated a renewed interest in diversified agriculture in these Islands. Although at that time the avocado was a rarity in the United States and scarcely known to the rank and file of American people, yet there were some persons here in Hawaii who thought even then that they could see a great industry capable of being built on this valuable and nutritious salad fruit of the tropics.

The interest was enough, at least, to prompt the new Hawaii Experiment Station, just then being established (1901), to turn its attention to the study of this fruit, among others. The many existing varieties were examined and

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<sup>16</sup>Haw. Agr. Exp. Sta. Bul. 51, p. 2, 1924.

more imported, with a view to finding some which would be superior for shipping to the states, and experiments were begun to devise the best way of sending this perishable fruit to Pacific Coast ports.

At that time the only known way of propagating the avocado was by planting seeds and trusting to nature for the results. Sometimes the seedling tree proved to be like the parent from which it came, but just as often it was a disappointment. The Experiment Station experts realized that an essential factor in the building up of an avocado industry would be the discovery of some method of propagating the tree vegetatively, to escape the uncertainty of using seedlings. After much experimenting the Station succeeded in developing a technique for budding young seedlings. This seemed to open the way to a large and important horticultural industry.

Then the Mediterranean Fruitfly came. In 1910 it was discovered and the discovery caused a furor in California, for it was feared that the great fruit industries of that state would be ruined if the pest should gain entrance there. A California state quarantine was quickly applied and in 1913 the federal government added a nation-wide prohibition against any importations of fruits from Hawaii which were known to harbor the fruitfly. The avocado was on the list of fruits thus banned, and that seemed to be almost a death blow to the potential avocado industry.

Meanwhile, there had been some pioneering souls in California, and others in Florida, who believed that this tropical fruit could be produced successfully on a commercial scale in those states, in spite of occasional frosts. Although the commercial plantings then were few and very small, many people had a tree or two as a novelty, and some of these became phenomenally valuable when the market began buying up the fruits at 50 cents apiece. This started a new gold rush—green gold, they called it. Commercial orchards began to make their appearance; those that were in comparatively frostless areas succeeded fairly well, but a large percentage did not. Avocado land took on a market value of \$2000 and \$3000 per acre, and a veritable boom was under way. The notion was prevalent that the American people would continue indefinitely to buy



unlimited quantities of the new fruit at the dizzy prices they were paying then.

By vigorous advertising, the consumption of avocados was greatly increased, but not as rapidly as the production increased. In California the 1924 crop was 129 tons, but in 1934 it had grown to over 9000 tons.<sup>17</sup> The Florida record was similar: 420 tons in 1929<sup>18</sup> and 2000 tons in 1934. When the 1934 crop in California was nearly five times as large as the 1933 and earlier crops, a natural result was that avocados were being sold (retail) at fruit stands for five cents apiece, where a few years before they would have commanded 75 cents and a dollar each.

This, obviously, has an important bearing on any plans or aspirations for an avocado industry in Hawaii, for even granting that the fruitfly quarantine were modified in such a way as to permit Hawaiian avocados to be shipped to the mainland states it would not be easy to compete with the California and Florida producers. In the past quarter century they have made great progress in perfecting their technique and placing the industry on a sound footing. Our exports would have to meet all the marketing expenses borne by the mainland product and much more in addition, for there would be the ocean freight in cold storage and the cost of special treatment of the fruit to make it exportable by the terms of the quarantine. The quarantine regulations, as they now stand, do not prevent avocado exports *if some treatment is applied which United States Department of Agriculture experts declare to be effective in making all the fruits non-carriers of the fruitfly*. Thus far, no effective treatment has been devised which is not detrimental to the avocado fruit itself. Mild heat, prolonged for some hours, is an effective way of killing the fruitfly in the fruits, but it causes a marked deterioration of the fruit and therefore cannot be used, although this method is useful for citrus fruits. Low temperatures, around freezing, kill the fruitfly if prolonged for a sufficient number of days, but this treatment injures the avocado and makes it unsalable. It is possible that some elec-

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<sup>17</sup>See U. H. Agr. Ext. Service, Agr. Notes 123, Jan. 8, 1936, for a forecast of much greater production in California in the next few years.

<sup>18</sup>Earlier statistics are not readily available.

trical treatment might be devised, but there is nothing very encouraging in sight.

To export avocados in some processed form is not only possible, so far as the quarantine is concerned, but is actually being done. No one has as yet devised a successful technique for canning this fruit; there is an exceedingly disagreeable odor and flavor which develops upon heating the fruit for sterilization in cans or jars. It may, however, be preserved in other ways, as in vinegar, without developing the offensive qualities noted above.

As a basis for salad dressing the pulp of the avocado is being exported, with some possibilities of a good market developing.

As a substitute for butter fat in the manufacture of ice cream it seems to offer some promise, provided its natural flavor is covered by the use of familiar flavors, such as lemon, pineapple, orange, etc. Avocado paste used thus with skim milk and flavoring extracts makes a smooth and delicious ice cream. In addition to local consumption, such a product could be exported and might find a large market, as avocado pulp is cheaper than butter fat.

In an earlier paragraph we noted that the fruitfly quarantine was almost a death blow to the potential avocado industry in Hawaii which seemed destined to develop into something of large importance. As a matter of fact it was not actually a death blow, for some interest continued and much hope was felt that somehow, sometime, the quarantine would be lifted or modified. The Hawaii Experiment Station kept its investigations going forward, and not a few individuals developed small commercial plantings. An association of interested people was formed about ten years ago, which worked for the advancement of the cause. The best encouragement came when the United States Bureau of Entomology transferred its Florida laboratory a few years ago to Hawaii and began a program of investigation aimed at discovering some effective means of treating the avocado and other fruits and vegetables for export.

At the present time there are two moderately large avocado orchards in these Islands, one developed by Dr. W. D. Baldwin on Maui and the other by the Hawaiian Avocado Company on Oahu. If these and all the scattered

plantings throughout the Territory were brought together it would probably cover an area of about 750 acres, with an estimated yield of about 600 tons.<sup>19</sup> This is small when compared with California's 10,000 tons and Florida's 2,000.

There are large areas of land here suitable for the avocado, but the present indication is that Hawaii would do well to think more of other crops which offer less difficult obstacles for large commercial development. For local consumption and perhaps for the manufacture and export of some avocado specialties there should be maintained something of an industry in the producing of this valuable salad fruit, but its prospects of developing into major proportions seem very distant and doubtful.

Ref.—Hawaii Exp. Sta. Bul. 51, "The Guatemala Avocado," 1924; Bul. 77:5-8 (uses of Avocado); Annual Reports 1902:321; 1904:381; 1909:51; 1910:25; 1911:25; 1912:36; 1915:23, 70; 1916:17; 1917:19; 1919:19; 1920:17; 1921:9; 1922:4; 1923:3; 1924:5; 1925:4; 1926:6; 1927:6; 1928:3; 1930:19; 1931:14; 1932:11; 1933:23; 1936:29. Also, Wilder, "Fruits of the Hawaiian Islands" (1911), pp. 6-11.

**AWA** Awa<sup>20</sup> or kawa (*Piper methysticum*), is either indigenous or was introduced many hundreds of years ago by the Hawaiians. It is a shrub, related to the plant from which the black pepper of commerce is made, and is widely distributed in Polynesia.

The root contains a soporific drug which the ancient Hawaiians had learned to use to produce an artificial relief from fatigue.

In the latter part of the nineteenth century something of an export industry developed around this drug plant, the chief demand coming from Germany where it was used in medicinal manufactures. The first shipment (1886) was small, about 4,000 pounds, and brought \$346. In the remaining years of the century this business increased a little, but never reached large dimensions, as shown by the following table of exports:

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<sup>19</sup>A large part of the plantings are still young and not yet producing at the maximum rate.

<sup>20</sup>Pronounced as though the "w" were a "v".

Year	Value
1886	\$ 346
1887	960
1888	3,550
1889	..... <sup>21</sup>
1890	.....
1891	.....
1892	776
1893	2,000
1894	.....
1895	1,304
1896	988
1897	.....
1898	409
1899	900
1900	1,642

The awa plant was usually not cultivated,<sup>22</sup> but allowed to grow of itself in certain favorable localities in the forests. Individuals desiring to gather it in the forests for sale to exporters purchased a license from the government.

At the present time there is practically no commercial exploitation of this plant, as synthetic substitutes have been developed which are cheaper.

Ref.—Thrum's Annual 1903:130-140 (O. P. Emerson, on the "awa habit" of the Hawaiians); export figures from earlier and subsequent issues. Haw. For. Agr. 1911:356-358. See also "Paradox in Hawaii" (D. L. Crawford), p. 130 (1933).

**BABASSU** Babassu oil is obtained from the kernels of the seed or nut of a palm (*Orbignya speciosa*) which is abundant in some parts of Brazil. Exports of this oil from Brazil have been increasing since 1915 to such an extent that some American farmers have become alarmed. At first the oil figured only in the soap trade, but now it is being used chiefly for edible purposes, in competition with domestic vegetable and animal oils and fats. It is a competitor of tung oil, also, in the manufacture of varnishes and paints.

While the babassu palm does not occur in Hawaii, it is believed that climatic conditions here would be well suited to it and efforts are being made by J. M. Westgate<sup>1</sup> to establish it here for commercial purposes.

<sup>21</sup>Figures not available for 1889-1891, 1894, 1897.

<sup>22</sup>J. G. Smith states that Magoon Brothers at one time cultivated more than 50 acres of awa in South Kona.

<sup>1</sup>Prof. Westgate was formerly director of the Hawaii Experiment Station. He has furnished most of the information contained in this statement about babassu oil.

**BAEL** See "Bhel Fruit."

**BAGASSE** Bagasse is a by-product of the sugar industry, being the fibrous residue remaining after the juice has been extracted from sugar cane. As about 22 per cent of the sugar cane consists of fibrous materials, nearly two tons of bagasse come out of the mill for every ton of sugar. At present, therefore, the total for the Territory is about 2,000,000 tons of bagasse. It is used in several different ways and has considerable economic value.

As fuel, one ton of bagasse is equivalent in value to about  $1\frac{1}{2}$  barrels of crude oil and it is in this way that most of it is used, for it can be conveyed directly into the furnaces, thus obviating the expense of baling and transporting it to more or less distant points for other uses. Bagasse being a very bulky commodity, this is an important feature.

As a feed for livestock, bagasse has some value and is used thus extensively on some plantations in combination with molasses. Honokaa Sugar Company, for example, has with good results fed to its mules a mixture consisting of 100 pounds dried, sifted bagasse, 100 pounds cane molasses and 40 pounds soybean oil cake meal. The same plantation manufactures a livestock feed composed of 45 per cent bagasse and 55 per cent molasses, to which the trade name "Karbotex" has been given. Some other plantations merely pour molasses over the bagasse and feed it thus to horses and cattle. Tests of Karbotex in the University dairy herd showed no saving in the cost of milk production when 50 per cent or more of the total ration consisted of this feed. In smaller amounts it may have a slight advantage over imported feeds.<sup>2</sup>

*Paper*—Bagasse is an important source of fiber for the manufacturing of paper and wall-board. Experiments and investigations by H.S.P.A. scientists, begun in 1910,<sup>3</sup> had a practical outcome when in 1919 the Olaa Sugar Co. undertook to make paper on a large scale for use in the cane fields as a means of curtailing weed growth between the cane rows. A large paper mill was erected, costing

<sup>2</sup>U. H. Agr. Dept. Annual Report 1929:16.

<sup>3</sup>See Planters Record II, 206-208; VI, 12-21; IX, 619-620; X, 82-87.



about \$300,000, and by a combination of bagasse fiber, cloth rags, waste paper and wood sulphite, a heavy mulching paper was manufactured in large quantities and saturated with a mixture of asphalt and fuel oil.

The mill continued in operation until 1928, manufacturing large amounts of paper each year<sup>4</sup> and supplying not only its own plantation but several others as well.

The use of mulching paper as a means of weed control in sugar cane fields did not increase, as it was at one time believed it would, but rather decreased. "Improved technique in field operations, combined with the spread in suitable locations of faster growing cane varieties, resulted in a general earlier closing in of the cane rows, so that fewer weedings were required and it was found that in general it is cheaper to eliminate the weeds by the use of weed poison and mechanical and hand weeding than to apply the mulch paper."<sup>5</sup> While pineapple plantations took up the use of mulching paper, the bagasse paper was not able to withstand weathering effects as long as some standard roofing papers.

As the demand for this locally made paper diminished, the operations of the mill were curtailed and finally, in 1928, brought to a close.

*Wall-board*—The manufacture of wall-board in Hawaii began in 1932. The Hawaiian Cane Products Company, organized in 1930, developed a large factory in Hilo to use the bagasse of two nearby sugar mills<sup>6</sup> in the making

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<sup>4</sup>According to information supplied by H. A. Walker, of American Factors, Ltd., the yearly output of the Olaa paper mill was as follows:

1919.....	1146	tons of saturated paper
1920.....	1133	" " " "
1921.....	1939	" " " "
1922.....	1826	" " " "
1923.....	2316	" " " "
1924.....	1881	" " " "
1925.....	2365	" " " "
1926.....	1214	" " " "
1927.....	1000	" " " "
1928.....	783	" " " "

This saturated paper consisted of two-thirds (by weight) raw paper and one-third asphalt and oil. The raw paper consisted of about seven-eighths bagasse fiber and one-eighth other fibers.

<sup>5</sup>Statement by H. A. Walker, President of American Factors, Ltd.

<sup>6</sup>Hilo Sugar Company, and Waiakea Mill Co.

of structural and insulation board to which the trade name "Canec" was given. Unlike the mulching paper mentioned above, this board required no additional fiber in its manufacture, the bagasse being sufficient for the purpose.

The factory began operating in 1932, at first with a relatively small output; in each succeeding year the business has grown, as shown by the following record of production:

1933—20,631,000 board feet  
1934—23,562,000 board feet  
1935—31,105,000 board feet  
1936—40,000,000 board feet (Approximately)

Shipments of this product go not only to the mainland United States but to many foreign countries, as Australia, Africa and countries of Europe and Asia. This is believed by some to be the beginning of a very large industry which will ultimately add much to the returns from the sugar cane crop of these Islands.

*Cellulose*—The making of alpha cellulose from bagasse offers some interesting possibilities. This substance is used in immense quantities in the making of cellophane and many other things, and bagasse appears to be an excellent source from which to obtain it on a large commercial scale. Experiments in the using of bagasse in this way are now being carried on in the laboratories of one of the sugar companies and may lead to an important development for the utilization of bagasse with more profit from it than now accrues from its use as a fuel.

**BALSAM PEAR** The balsam pear (*Momordica Charantia*) is somewhat like a small cucumber in general shape, but has a warty and irregularly ribbed surface. It is the fruit of a vine which thrives very well in Hawaii and is cultivated by Chinese gardeners to a moderate extent. Unfortunately, the fruits are very susceptible to attack by the melon fly and have to be protected by being enclosed in a paper bag.

The balsam pear is harvested in the immature stage and is used especially by the Chinese in combination with certain meat dishes.

A recent crop survey (1936) showed about 20 acres devoted to this crop.

Ref.—Haw. Exp. Sta. Bul. 60:33, 1929.

**BAMBOO** Several species of bamboo (*Bambusa spp.*) have been introduced into Hawaii from the Orient and are well established. In addition to many small plantings in gardens and estates, there are several of large extent, 100 acres or more. These latter are used as a source of fishing poles and similar articles and the owners more or less regularly supply the local market. In a very small way the building trade uses this product for novelty structures, while furniture manufacturers also draw upon the local supply to a small extent, their preference being for imported stocks.

In the Orient certain species of bamboo are used as a source of fiber for the manufacture of paper, and it has been suggested that such an industry could be established here in Hawaii.<sup>7</sup> There is no doubt but that the bamboo can be produced here with ease, and by utilizing some of the cheap, marginal lands the cost of production could be kept at a low figure. This is a possibility which ought to be considered carefully in any broad plan for diversification.

The young shoots of several species of bamboo are commonly used as food in Hawaii, especially by the Chinese and Japanese people. The bamboo is a giant type of grass, and propagates itself by underground, root-like stems which at frequent intervals send up vertical stems. These latter emerge from the ground as thick, sharp-pointed shoots enclosed in several layers of leafy bracts. These shoots, when stripped of their bracts, are sufficiently tender and succulent to be eaten when cooked.

There are several species of such edible bamboo in Hawaii, all having come originally from the Orient. Bamboo shoots are offered in the city markets throughout the year, with a small but appreciable business in them resulting.

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<sup>7</sup>Haw. For. Agr. 1910:221-223; 1913:163.

**BANANA** The banana (*Musa sapientum*), perhaps the first of all the fruits brought under cultivation by man, was introduced into Hawaii by the Polynesians long before Captain Cook's time. It was an important element in the diet of the early Hawaiians, being one of the relatively few fruits available to them.

It can scarcely be said that they cultivated the banana, but they did go to some pains to establish their plantings in mountain gulches and valleys where they could be more certain of a perpetual water supply than in the lowlands. To a limited extent there was natural dispersal by the force of freshets, so that the supply of the fruit increased.

There seem to have been a considerable number of varieties of banana brought in at various times by the early Hawaiians, but none of them proved to be of great commercial value in the modern era. Most of them are now extinct.

In the nineteenth century a dwarf variety, now known as the Chinese or Cavendish banana (*Musa Cavendishii*), came in a roundabout way from South China through England and the South Sea Islands and finally to Hawaii about 1855. In a relatively few years it had established itself as the most important and valuable of all the banana varieties here, for it had great vigor and productiveness and the fruit was of excellent flavor and quality.

The Brazil variety, good but not quite as valuable as the Chinese, was introduced into Hawaii about the same time, and proved to be an important addition to our list for local consumption, but not for export.

The new interest in agriculture which sprang up immediately following annexation resulted in some special attention being turned to the banana as a basis for a new industry. A general survey of the situation in 1903 by the newly established Hawaii Experiment Station suggested the desirability of bringing in some of the tested Central American varieties which were well known in the markets of the United States. Accordingly, in 1904 several lots of the Bluefield or Jamaica variety were imported for trial, and several others besides.

The Bluefield did well in certain localities, but it has never really established itself here on a wide commercial scale. The trade winds are too stiff, except in protected areas such as Kona. The Panama disease was first recognized in Hawaii in 1911, though it probably had been present even before 1900. It has been an important factor in retarding the spread of this variety.

Although banana production has received a good deal of attention in Hawaii in the past thirty years it has not become a large industry. As a matter of fact, Hawaii is not considered a particularly good banana country, for most of the land that is not used by the more lucrative sugar industry is of rough topography and not suitable for the application of large scale production methods. The prevalence of rather stiff trade winds in most localities where the soil is good and the rainfall adequate makes it difficult to produce the Bluefield, which is the only variety that would be marketable on a very large scale. Even if these factors were omitted from consideration, there would remain the relatively high wage scale here as compared with Central America; also, the cost of land is much higher.

Bananas have been shipped from Hawaii to the Mainland in moderate amounts ever since 1856. Beginning with 93 bunches in that year, the annual shipments gradually increased to over a thousand in 1864 and passed the 10,000 mark in 1875; by 1885 they were over 60,000, and in 1889 were in excess of 100,000 bunches; with some fluctuations the shipments remained at about that figure until 1911 when they began increasing again rapidly, going to a maximum of 280,000 in 1915, then dropping off a little to an average of about 225,000 to 250,000 bunches per year until 1928, then declining considerably below that level in subsequent years. In 1935 the total exports were 98,296 bunches.

Compared with imports from Central America into the United States a hundred thousand bunches per year is a mere "drop in the bucket," for banana imports into the United States in 1910 were reported as being over 40,000,000 bunches and in 1930 over 65,000,000.

Small as these shipments are in comparison with total



mainland imports, they constitute an important item in Hawaii's list of agricultural exports. The following tabulation shows the gross returns from banana shipments during several years:

<i>Year</i>	<i>Value</i>	<i>Year</i>	<i>Value</i>
1910.....	\$ 51,229	1923.....	\$212,624
1911.....	108,414	1924.....	211,343
1912.....	140,720	1925.....	255,614
1913.....	143,472	1926.....	245,465
1914.....	126,455	1927.....	247,703
1915.....	189,578	1928.....	216,802
1916.....	166,977	1929.....	184,531
1917.....	170,368	1930.....	201,227
1918.....	90,988	1931.....	118,410
1919.....	102,796	1932.....	103,805
1920.....	176,020	1933.....	79,708
1921.....	151,968	1934.....	85,811
1922.....	214,255	1935.....	92,536

Local consumption absorbs probably as much as the total of exports, thus doubling the economic value of this industry over the figures tabulated above. Thus, banana production was worth in 1925 something like \$500,000, and now perhaps \$200,000 per year.

A very important feature enhancing the value of this crop to Hawaii is its potential usefulness in time of war or other emergency which might cut off normal imports of foodstuffs into these islands.

The banana is a very nutritious and palatable food, capable of being used in a great variety of ways to supplement other foods which are produced locally. The normal yield of bananas in these islands, including the usual exports, is about 8 to 10 millions of pounds per year, equivalent to about 20 to 25 pounds per capita. Production is distributed widely throughout the Territory, thus reducing the cost of transportation to the consumer; and the fruit ripens throughout the year, which makes it the more valuable as an emergency food crop. It would be a wise expediency, therefore, if all available means were used to keep the banana industry at least at its present level; perhaps it might well be extended.

There are two interesting possibilities in the way of manufactured products: canned bananas and dried bananas.

Certain varieties of cooking bananas, as the Popoulu, if attractively canned, might find a large market. These fruits, being short and thick, would fit a can neatly.

Some of the very sweet varieties which do not ship well can be dried into a delicious and nutritious food product, marketable on a basis more or less equal to dates, figs and other fruits when prepared as sweets. In Europe the dried banana is in as much demand as dried figs, dates and prunes.<sup>8</sup>

There are other commercial possibilities, as banana flour, and banana beer,<sup>9</sup> but none as promising as the two foregoing. It is conceivable that either or both of these manufacturing processes might open the way to a very great enlargement of the banana industry. On this basis the industry could expand greatly, but otherwise it is probable that banana production will not in the future become a factor of any materially greater importance in the economic life of these Islands than it is now.

Banana fiber has been extracted from the stalk in southern Asia and used in the manufacture of cloth. This has not been attempted in Hawaii, although the idea was suggested many years ago.<sup>10</sup> Manila hemp is made from a closely related species of plant and it seems likely that the banana might be a good source of commercial fiber.

Ref.—Haw. Exp. Sta. Bul. 55, "Banana Culture in Hawaii," 1926; Bul. 77:9-13 (on uses of banana); Annual Reports 1904:379; 1905:59; 1906:11; 1908:44; 1911:32; 1912:41; 1917:40; 1918:13, 36; 1919:51; 1921:13; 1922:2, 12; 1923:4, 8; 1924:4; 1927:10. Ext. Bul. 6, "The Banana as an Emergency Food Crop," November, 1917. Univ. Haw. Agr. Studies No. 5, "Bananas in Hawaii," Sept. 1927. Thrum's Annual 1890:79-81; 1927:106-110 (list of varieties, by W. T. Pope). Also, an unpublished thesis by W. T. Pope with very comprehensive information on all varieties known in Hawaii. Haw. For. Agr. 1904:199-205; 1906:104 (banana flour); 1911:40 (dried bananas). Planters Monthly XI, 119-121 (flour, and dried product).

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<sup>8</sup>According to F. G. Krauss, who has recently returned from Europe, the average quality of the dried banana product sold there is not equal to that of the product made locally on an experimental scale.

<sup>9</sup>Banana beer is a product developed in Africa and said to be an effective remedy for malarial fever. Those who had sampled it declared that they preferred the malaria. (Planters Monthly, Vol. V, p. 24 [1886].)

<sup>10</sup>Haw. For. Agr. 1904:174-183; 1911:39.

**BATS** The introduction of insectivorous bats was urged by Frederick Muir and H. L. Lyon<sup>11</sup> in 1914, as a means of reducing the mosquito nuisance. Thus far, however, the suggestion has not been put into effect.

**BAYBERRY** The bayberry tree (*Myrica cerifera*), source of a commercial wax used in the manufacture of certain types of candles, was introduced into Hawaii a few years ago by the H. S. P. A. Experiment Station. It is flourishing here and spreading by natural means of dissemination into the wild state.<sup>12</sup>

**BAY RUM** Bay rum of commerce is an extract from the leaves of *Pimenta acris*. This species of tree has been introduced into Hawaii in recent years, and thriving specimens in Kona and other districts give evidence of its having found conditions here suitable. There seems to be no tendency toward wide planting of the tree, however, and no effort to establish an industry for the manufacture of bay rum.

**BEANS** Next to the cereals, beans and peas are probably the most valuable of all the plants domesticated by man, for they not only furnish exceptionally nutritious food but enrich the soil at the same time by the help of nitrogen-fixing bacteria which live in the roots.

The first introduction of beans into Hawaii was by the white people. Although Don Marin speaks of planting beans in 1813, that is probably not the first instance of such planting, for dried beans were an inevitable part of the food stores of all European and American ships and it is quite likely that some were planted in this new land considerably before Marin's diary entry was made. It is not strange that the Hawaiians were not cultivating beans before the coming of white men, for the Polynesian people had never used any legumes as food, and on their coming to these islands found none here suitable for eating.

During the nineteenth century many species and va-

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<sup>11</sup>Planters Record Vol. XI, 105.

<sup>12</sup>Information furnished by Dr. H. L. Lyon, Director, H.S.P.A. Experiment Station.

ieties of beans and peas were introduced here from various parts of the world, some by Occidentals and some by Orientals. A few of these have become widespread and are of considerable economic importance: notably the pigeon pea, the algaroba (kiawe), etc. Most of the introductions, however, are of only minor importance among the present products of this Territory, for Hawaii has never been much of a bean producing region<sup>13</sup> in spite of the fact that there are many kinds and varieties which can be grown here very successfully.

Consumption of beans and peas in Hawaii amounts to a large annual total, probably fully 5,000,000 pounds when both the canned and dried forms are included with the local fresh products; and most of this is imported from outside, the value of the imports being something like \$250,000 per year.

Some of the principal kinds of beans and peas which have been or are of some considerable economic interest here are the following:

I. Used as livestock feeds:

1. Algaroba
2. Cowpeas
3. Pigeon pea
4. Soybean

II. Used as human food:

A. Seeds only, dry, fresh or canned:

1. Lima bean
2. Mungo beans
3. Pea (garden pea)
4. Peanut
5. Shell beans
6. Soybean

B. Pods and seeds:

1. Chinese pea

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<sup>13</sup>During the World War period there was a larger planting of beans here than at any other time, the maximum having been about 1000 acres of both red kidney and white navy varieties. Difficulties were encountered in the drying of the beans, because of humidity of the atmosphere.

2. Cowpea
3. Goa bean
4. String bean (snap bean, wax bean)
5. Yard long bean

C. Sprouted seeds:

1. Mungo bean
2. Soybean

While bean production on a regular commercial scale would not be as profitable here as cane sugar, nevertheless as a means of utilizing certain idle lands and especially as an interim crop between the harvesting of a final ratoon crop of sugar or pineapples and the next planting, it might be possible to develop an industry of considerable magnitude in the production of certain kinds of beans and peas. There are several attractive possibilities: green string beans, dry field beans, pigeon peas and soybeans.

Several varieties of green string beans, as the Kentucky Wonder, do exceptionally well here, and could be produced in large quantities in the winter months when the mainland markets are but scantily supplied. If a way can be found to treat the green product so that it will not be the means of introducing the melon fly into the mainland states (at present string beans are prohibited from entry by quarantine laws), there might be developed a seasonal industry of great importance to these Islands. Especially would this be true if our canning plants would extend their range of activities to handle string beans in those seasons when shipment in the fresh state does not pay. In this way producers would be protected somewhat from loss, by having two outlets for the crop.

Production of dry beans, likewise, could be developed to large proportions on fallow lands or as an interim crop. The local market could absorb large quantities, and there would be the additional prospect of shipping to outside markets in large quantities, if production costs could be kept at a low figure. Past experience here indicates that this crop should yield a net return of \$30.00 to \$50.00 per



acre when the prevailing price for beans is 4 to 5 cents per pound.

The pigeon pea, discussed also under its own heading, is usually thought of only as a feed for livestock. As a food for humans the pigeon pea offers interesting possibilities. In India, some parts of Africa and in Porto Rico it is an important and much relished article of diet, eaten in the same ways that other beans and peas are used. Hawaii, with thousands of acres of this crop, is overlooking a good thing so long as no effort is made to commercialize it for human consumption, whether dry or canned. As a war emergency food it certainly must not be overlooked.

Soybeans offer some promise of being profitable in Hawaii, both for use directly as a food for humans and livestock and also for a number of industrial purposes. Large quantities of soybean products are shipped in every year; some well conceived plan ought to be put into effect to develop a soybean industry here.

*Bean Sprouts* By allowing beans to germinate and grow for a few days in darkness a succulent, nutritious food is produced. Two species of beans are commonly used for this in Hawaii, the soybean (*Glycine hispida*) and the mungo bean (*Phaseolus aureus*). The former produces a sprout about 3 inches long, the latter about half that length.

The seeds are soaked in water for 24 hours and then spread out between layers of wet burlap or woven mats which are moistened at six-hour intervals for four to six days. The sprouts are then ready for consumption and must be used within a day or two to be at their best.

See also various headings as listed in the tabulation above; also see "Truck Crops."

Ref.—U.H. Agr. Ext. Bul. 16, "Vegetable Production in Hawaii," pp. 59-69, June 1932; Haw. Exp. Sta. Ext. Bul. 3, "Beans as an Emergency Food Crop," 1917; Haw. Exp. Sta., Annual Report 1918:16; 1921:31; 1928:16; Bul. 64, "The Pigeon Pea," March 1932. Beans and other legumes as soiling crops (green manure): Planters Record (H. S. P. A.) Vol. II, 256; III, 51-63; V, 200-210.

**BEEF CATTLE**<sup>14</sup> The beef cattle industry of Hawaii was well established before the growing of sugar cane on a commercial scale was begun. Vancouver brought the first cattle to Hawaii in 1793. These cattle, which were Longhorns secured in California, were protected by a strict tabu for a number of years and by 1830 had greatly increased in number.

Mexican cowboys were brought to the Waimea plains about 1830 and they taught their worthy successors, the Hawaiian cowboys, how to conquer and manage the wild herds of cattle on the slopes of Mauna Kea.

By 1850 the practice of penning and domesticating the cattle rather than hunting them with the horse and lasso had become established and has continued until today the vast pastures of the early days have been fenced and cross fenced, making possible the segregation of different classes of cattle and also the resting and rotating of pastures. This, in turn, has made possible the introduction and planting of improved grasses<sup>15</sup>—a matter in which the ranchmen of Hawaii are much interested.

Cattle in 1853 were worth five dollars per head. Even as late as 1875 it was reported that the hides and tallow were of more value than the meat, but this situation changed following Annexation and the development of refrigeration.

Modern English breeds, notably the Hereford, Shorthorn, Angus, Dexter, and Devon breeds were brought to Hawaii beginning about 1850, and by 1900 they had largely replaced the original Longhorns. About 1890 the Hereford began to gain an ascendancy over the other breeds and today over 90 per cent of the beef cattle in Hawaii belong to this breed.

Hawaii is now producing about 15 million pounds of dressed beef annually, valued at about \$2,100,000. The 1930 census credits the Territory of Hawaii with about 130,000 beef cattle, on some forty large ranches and some smaller ones located on all the islands. The Island of Hawaii has about 68 per cent of the total beef cattle in the Territory; Maui has about 16 per cent; Kauai, 5 per cent;

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<sup>14</sup>This statement was prepared by Prof. L. A. Henke.

<sup>15</sup>For a list of these, see "Range Grasses."

Oahu and Molokai each have 4 per cent; Lanai, 2 per cent; and Niihau, 1 per cent. Approximately one-third of the total beef cattle in the Territory are found on one large ranch and its associated ranches on the Island of Hawaii.

The number of beef cattle has not changed greatly in the past forty years. As former ranch lands were taken over for sugar and more recently for pineapple production, improved pastures and better systems of management made it possible to carry approximately the same number of cattle on the reduced area.

The area devoted to beef production in the Territory is large, totalling about 1,300,000 acres and comprising about one-third of the area of the entire Islands. While there are fine pastures in this area, there are also thousands of acres of barren lava flow country of which 100 acres or more are required to support one animal. The average for the entire ranch area in the Territory is one head to 10 acres, but there are favored areas planted to pigeon peas or improved grasses in regions of ample rainfall where only one to two acres are required per head.

*Water Supply Important*—Formerly it was necessary for cattle to walk long weary miles to water, but this has been largely changed and hundreds of miles of pipe lines now bring water to the cattle. However, there still are areas where securing drinking water for the cattle during the dry season is a major problem. Large galvanized iron roofs are constructed to catch rain water from where it is led to large storage tanks to be used as needed. More of these are needed as a protection against occasional long periods of drought.

*The Breeding Season*—Many ranches have a definite breeding season lasting perhaps three or four months during which time the bulls are allowed to range with the cows. This is usually so timed that the calves will be born during the season of the year when the pastures are in best condition, often the winter months because of the greater rainfall at that time, although this varies in different parts of the Territory. This scheme facilitates the handling and segregation of the calf crop but requires more bulls than the plan followed by other ranchers who permit the bulls to run with the cow herd throughout the

year. The number of bulls required varies with the character of the range; in rough country having a low carrying capacity more bulls are required. One bull for each twenty-five cows is approximately the average ratio maintained. Ranchers who permit the bulls to range with the cows throughout the year maintain that this results in a larger calf crop.

*Marketing Methods*—Due to better, earlier maturing cattle, better pastures, and better systems of ranch management, cattle are marketed at a much earlier age now than formerly. From the better ranches, market steers now average between two and three years of age and produce a dressed carcass weighing between 550 and 600 pounds. Thirty years ago it required four to five years to produce a steer of this size.

The largest slaughter house with Federal inspection of the carcasses is located in Honolulu and slightly over half of the beef produced in the Territory is slaughtered at this plant. The number, average weight and prices paid in 1935 follow:

Class	Number	Average Dressed Weight lbs.	Average Price Paid Per Pound cents
Steers .....	7983	593	14.54
Heifers .....	2804	413	14.19
Cows .....	2115	499	12.04
Calves .....	274	102	12.16

Most of these animals came from the Island of Hawaii. At present, few or no live cattle from Maui are shipped to Honolulu for slaughter, but dressed carcasses totalling over one quarter of a million pounds were sent from Maui to Honolulu in 1935.

Cattle from the Kona side of Hawaii are loaded on the steamers by being driven into the ocean, tied to small boats and forced to swim to the steamer where they are lifted on board by means of a crane.

Most ranches have small slaughter houses where enough cattle are killed to supply the local needs. Many plantations have a small beef herd which graze on lands not suitable for sugar cane and these are generally slaughtered at the plantation for local use.

Since the beginning of the industry in Hawaii, cattle have been marketed directly from the pastures without any supplementary feeding on concentrates. As the pasture grasses were improved, a better quality of beef resulted and in recent years the beef produced on improved pasture grasses, pigeon peas, and koahaole<sup>16</sup> has been of very good quality although hardly equal to grain-fed steers.<sup>17</sup> Increasing quantities of cane molasses<sup>18</sup> are now being fed on some ranches, and experiments now in progress indicate that this is a very desirable practice, resulting in heavier carcasses at a given age and providing another use for the large quantity of cane molasses available in the Territory. Cane molasses is a cheap feed in Hawaii and it appears that using it in this way gives a better return for the molasses than other present available ways of disposing of it, and besides results in better beef. It is likely that this practice will increase. The common method is to supply the molasses in open troughs in the pastures. Experiments are also in progress at this time which may demonstrate that feeding some protein supplement, as soybean oil cake meal or perhaps fish meal, is desirable.

The Army and Navy in Hawaii purchase large quantities of beef. This is purchased on the basis of Federal grades, with requirements that it grade as "good" or better; much of the locally produced beef does not at present meet this requirement, either because the carcasses are too small or do not grade high enough. Practically all of the Navy beef is secured from local sources, but most of the Army beef is produced on the mainland. It is anticipated that the more general use of local low cost feeds, as cane molasses and pineapple bran, may make it possible to produce more and better carcasses so that much of the Army beef can be supplied from local sources. Cereal grains that are ordinarily used to fatten cattle in the Middle West are too costly in Hawaii, for they must be imported.<sup>19</sup>

### *Imports Compared With Local Production—A survey*

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<sup>16</sup>See "Koahaole."

<sup>17</sup>A study of the digestibility of various locally produced feeds is under way at the Hawaii Experiment Station. See Annual Report 1936, p. 72.

<sup>18</sup>See "Molasses" and "Bagasse."

<sup>19</sup>See "Corn," "Wheat," etc.



of the beef situation in Hawaii made in 1928<sup>20</sup> indicated that local production in that year totalled about 14,213,000 pounds of dressed beef, and during the same year 4,104,883 pounds of beef and veal were imported, or 22 per cent of the total beef consumed during that year was shipped to Hawaii. Ninety-six per cent of the beef shipped to Hawaii that year came from foreign sources.

During 1935, 4,568,934 pounds of fresh or frozen beef and veal were shipped to Hawaii; with an estimated local production of 15,000,000 pounds, about 23 per cent came from sources outside of the Territory. It is interesting to note that of the total fresh beef and veal shipped to Hawaii in 1935, ninety-five per cent came from the mainland United States, almost a complete shift in the situation as recorded for 1928.

In addition to fresh beef and veal, 2,021,057 pounds of pickled, cured or canned beef were shipped to Hawaii in 1935, making a total of about 21,600,000 pounds of beef consumed that year, or an average of slightly in excess of 50 pounds per capita, which figure compares rather closely with average mainland consumption.

**BEEES AND BEEKEEPING** Beekeeping, a very ancient art and probably the first means of supplying a sweet in human diet, was unknown in Hawaii until comparatively recent years because of the absence of the honey bee. Although insects of many species had gained entrance to these Islands by flight or otherwise, this useful species was not represented here when Captain Cook's discovery voyage opened the modern era in 1778.

During the next eighty years there were many times when the white settlers longed for fresh honey and wished that beekeeping might be established as an industry here. However, to transport a living swarm of bees from the Atlantic Coast around Cape Horn on a voyage which took several months seemed to be an almost insuperable difficulty. In 1853 an effort was made to bring two hives from Boston, one of them packed in ice to keep the bees dormant in a simulated winter. The experiment cost

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<sup>20</sup>Henke, L. A. A Survey of Livestock in Hawaii, University of Hawaii, Research Publication No. 5 (1929), pp. 1-82.

\$150 but was not successful, for neither swarm survived the trip.

In 1857 the first living swarm was established here, but for many years thereafter beekeeping was carried on simply as a household activity, with no important development commercially.

The first commercial venture in the production of honey and beeswax for export and general sale began in 1895, with the first exports in 1897, some 109,000 pounds.

At the beginning of the present century honey production was a considerable industry, with three corporations engaged in it and a capital investment of about \$150,000. Nearly all the product was sold in Germany, some in the United States mainland, but very little of it was consumed locally. While large quantities of bulk honey were going out each year, a not inconsiderable amount of bottled honey was being imported for use by our local population.

In 1905 the Hawaii Experiment Station began directing some of its attention to this industry, for the annual crop was being greatly increased about that time by the presence in the sugar plantations of large quantities of honey dew secreted by the leafhopper, which then was exceedingly abundant. New strains were brought in by the introduction of improved queens, and efforts were made to increase the number and range of honey yielding plants.

An association of beekeepers was organized in 1907, to advance and protect the interests of the industry. One result of their efforts was to have a quarantine order issued by the Territorial Board of Agriculture to control the importation of bees as a protection against the foul brood disease which, fortunately, had not gained entrance to Hawaii.

By 1908 the industry had expanded to cover all the islands, with seven corporations and many individuals operating a total of about 20,000 colonies of bees. The industry continued to grow, the annual value of its product increasing from \$40,000 in 1910 to the all-time maximum of over \$300,000 in 1919, when phenomenally high unit prices greatly enhanced the year's returns. Subsequent years have brought forth large amounts of honey but

the values have been much less than in the bonanza years of 1919 and 1920, as shown by the following table, in which honey and beeswax exports are combined:

Year	Value	Year	Value
1903.....	\$ 15,280	1920.....	\$211,508
1904.....	14,346	1921.....	79,963
1905.....	24,605	1922.....	65,853
1906.....	40,793	1923.....	85,765
1907.....	31,053	1924.....	99,464
1908.....	36,882	1925.....	107,495
1909.....	50,412	1926.....	114,832
1910.....	41,388	1927.....	88,687
1911.....	63,543	1928.....	73,033
1912.....	46,104	1929.....	105,115
1913.....	67,811	1930.....	114,897
1914.....	46,517	1931.....	97,159
1915.....	49,169	1932.....	67,528
1916.....	70,509	1933.....	33,664
1917.....	69,959	1934.....	42,091
1918.....	170,638	1935.....	69,178
1919.....	329,599		

In spite of quarantines, the foul brood disease finally did make its appearance here and has become a serious handicap to the industry. Although efforts are being made to control it, probably the disease can never be eradicated from the Islands. Other than this and the bee moth there are no very serious enemies of the industry.

The algaroba is the main source of honey here, and practically all the extensive areas occupied by this tree are covered by existing apiaries. It would seem, therefore, that this is one industry which ought to be and probably will be maintained at about its present level of development without material increases in the number of colonies.

Ref.—Trans. Royal Haw'n Agr. Soc., Vol. I, No. 3, p. 116; II, No. 1, pp. 53-60 (1854). Thrum's Annual 1906:46; statistical data from subsequent issues.

**BEET** The production of the common edible beet (*Beta vulgaris crassa*) is a familiar feature of nearly all truck gardens in this Territory. Several varieties<sup>21</sup> do well under Hawaiian conditions and there is a constant demand for a limited amount of the product, for the beet is a widely used food. In addition to the root, which is the part most commonly marketed, the tops are excellent as greens and frequently are used in this way.

<sup>21</sup>See Agr. Ext. Bul. 16, p. 69 for their names.

The area now used for commercial production of beets to meet the local demand is less than 50 acres, exclusive of home gardens. The chief demand is from the Caucasian peoples, the Orientals and Hawaiians having other root crops which take the place of the beet. It should be noted, however, that something less than the entire consumption demand is met by local production, for some 50,000 pounds of mainland beets are brought in annually by local vegetable dealers.

An attempt to grow sugar beets for the manufacture of sugar was made on Lanai some years ago before the island was acquired by the Hawaiian Pineapple Company.<sup>22</sup> The effort was not successful.

See also "Truck Crops."

**BEGGAR WEED** The giant beggar weed (*Desmodium tortuosum*) has proven to be good as a soiling crop (green manure), as it makes rapid growth under Hawaiian conditions and produces an abundance of root nodules. Ref.—Planters Record (H. S. P. A.) III, 53.

**BERMUDA GRASS** Bermuda, or manienie<sup>23</sup> grass (*Cynodon Dactylon*), forms the foundation of most of the pastures of Molokai, Maui, Oahu, and Hawaii from sea level to elevations of 4,000 feet. A giant variety is under trial.

Ref.—Haw. Exp. Sta. Bul. 65:15, 1933.

**BETEL** The leaves of a pepper (*Piper betle*) are used in flavoring certain foods by the Chinese, and a limited demand exists both here and in California. The betel pepper is a tropical plant, cultivated throughout the East Indies and southern Asia.

It was introduced into Hawaii many years ago, exports of the leaves to San Francisco having been made as early as 1875, when 100 "boxes" were shipped.<sup>24</sup> The leaves are picked and packed fresh in small baskets or boxes.

A small business has been maintained in this way, with total annual shipments never reaching a high figure, how-

<sup>22</sup>Authorities for this statement are F. G. Krauss and J. G. Smith.

<sup>23</sup>This name is said to have been derived from that of the Spaniard, Don Marin. It is the Hawaiian equivalent of his name.

<sup>24</sup>Thrum's Annual 1878:59.

ever. Within the past five years it seems to have been discontinued and the cultivation of the plant has nearly ceased.

In some tropical countries the betel pepper is used as a drug; after stripping off the husks of the betel nut<sup>25</sup> palm seed, the seed itself is cut into thin slices or sections and placed on the betel leaf with a little lime added, then the leaf is rolled up and chewed. It is said to have the effect of seeming to relieve fatigue, somewhat as awa root.

**BETEL NUT** The betel nut is the seed of a palm tree (*Areca catechu*) which is grown extensively in Hawaii as an ornamental. The fruits are globular, an inch or more in diameter and orange colored, with a fibrous husk enclosing a single seed. In some tropical countries the seed is chewed by the natives (see "Betel"), but in Hawaii very little use is made of it.

**BHEL FRUIT** The bhel, or bael (*Aegle Marmelos*), is a tropical fruit tree sometimes grown in Hawaii as an ornamental. It is spiny and has trifoliate leaves. Its fruit resembles an orange in appearance and size, but its outer rind is hard and gourd-like. The juicy pulp within is pleasantly acid in flavor. There is no commercial production of this fruit.

**BLACKBERRY** The common blackberry (*Rubus spp.*) of the temperate zone has been introduced into Hawaii and grows wild in certain upland areas, as in the vicinity of the Kilauea Volcano, and the Olinda region on Maui. To a limited extent it is cultivated in home gardens at elevations of 3,000 to 5,000 feet above sea level, but the total production is not sufficient to be of economic importance. As a rule the berries are small and seedy in comparison with the mainland product.

**BOWSTRING HEMP** See "Sansevieria."

**BRAZILIAN PLUM** The Brazilian plum (*Eugenia brasiliensis*), also called Spanish cherry, is used in Hawaii only as an ornamental shrub or tree. The fruit resembles

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<sup>25</sup>See "Betel Nut."



a small guava in shape, but is purplish-black in color; although edible, it is not used to any considerable extent.

**BREADFRUIT** Breadfruit (*Artocarpus incisa*) is the staff of life in certain islands of the South Pacific. While in Hawaii it has never filled a place quite that important, it was looked upon by the old-time Hawaiians as an exceedingly valuable item of their diet. In earlier times there were many more breadfruit trees growing in the Islands than there are now, for during the past hundred years the demand for this fruit has diminished almost to the vanishing point and once flourishing groves have been allowed to die from neglect, or they have been crowded out by other crops that seemed more profitable.<sup>26</sup>

In the 1920's there developed a renewed interest in this tropical fruit, due largely to the enthusiasm and exploratory work of the late G. P. Wilder, who made a number of trips to the South Seas and sent some fifty or more varieties of breadfruit cuttings to Honolulu. Because of the extreme difficulty in propagating this tree, not more than half of the importations became established here.

The Hawaii Experiment Station in 1921 began some propagation studies which resulted in the development of an effective technique, consisting of laying in sand a six-inch bit of surface root of the breadfruit tree removed in the dormant season just after the fruiting period. After several months these pieces of root send up shoots which grow into new trees. The breadfruit develops no seeds, hence the necessity of this procedure.

Eaten in the usual manner, this fruit will probably never be in great demand except among those local people who have cultivated a liking for the peculiar flavor and texture. If, however, a way were discovered to use the breadfruit in the manufacturing of some prepared or processed food product, it might be possible to develop something of an industry around this fruit. The tree is large and requires much space; grown commercially, an acre would support about 15 to 20 trees. The yield would average perhaps

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<sup>26</sup>There are many scattered trees in the gulches along the Hamakua coast of Hawaii, bearing heavily, but most of the fruit is allowed to waste.

about 200 or 400 pounds per tree after a good degree of maturity is reached.

Ref.—Haw. Exp. Sta. Annual Reports, 1921:21; 1923:4; 1925:7; 1927:7; 1928:9; 1936:94; also, Bul. 77:14-16 (uses of breadfruit); Wilder, "Fruits of the Hawaiian Islands" (1911), pp. 100-107. Planters Monthly Vol. XIII, p. 315 (1894).

**BROCCOLI** Broccoli (*Brassica oleracea botrytis*) is a relative of the cabbage and cauliflower, and like the latter produces an abundance of small flower buds which with the associated leaflets and stems constitute the edible portion.

Broccoli is grown successfully in Hawaii, especially at higher elevations, but its production is insufficient to fill the existing demand. A recent crop survey (1936) indicates that this plant occurs in truck gardens on all the islands, but more extensively on Maui than on the others; the total acreage is probably less than 30 acres. Nearly as much is imported from California as is produced in the Territory; the total consumption here is between 125,000 and 150,000 pounds, of which local production provides about 80,000 pounds.

See also "Truck Crops."

Ref.—U.H. Agr. Ext. Bul. 16:78, 1932.

**BROMEGRASS** Brome grass (*Bromus unioloides*) does well with Bermuda and certain other grasses and provides excellent pasturage. It is one of the favorites of Parker Ranch.

Ref.—Haw. Exp. Sta. Bul. 65:11, 1933.

**BROMELIN** Bromelin is a digestive enzyme in the pineapple, resembling and possibly identical with the well known papain from papaya, which is well known in commerce and used in the manufacture of certain patented preparations used as aids to digestion.

Investigations in the P.P.C.A. Experiment Station<sup>27</sup> at the University indicate that bromelin of very good quality could be extracted from the pineapple fruit and possibly, also, from the leaves, as a commercially valuable by-product.

<sup>27</sup>By O. C. Magistad and F. A. Abel; Dr. C. P. Sideris made preliminary studies of the enzymatic reactions of pineapple leaves.

**BROOM CORN** There are three broom factories in Honolulu, including one operated for and by indigent blind men. These factories have to depend on imported broom corn (*Sorghum vulgare technicus*), for none is produced in Hawaii on a commercial scale. The amount consumed here in local manufacture is not large, about 125 tons per year, but it is an item of some importance when one is considering the diversification of agriculture in these Islands.

From 1910 to 1912 the Hawaii Experiment Station made some tests to determine the possibilities of producing this crop here. While the tests were not very extensive, they seemed to be sufficient to show that a good quality of broom corn can be grown in Hawaii, with a yield of 300 to 600 pounds of brush per acre. A later test in 1927 was not encouraging. Some of the locally produced brush was used in a Honolulu factory and found to be satisfactory.

Insect enemies, especially the aphid, are a serious menace to this crop in the lowland regions. It is possible that in the higher lands, at elevations about 3,000 feet, broom corn might be grown with moderate profit to the producer.

Ref.—Haw. Exp. Sta. Annual Reports 1910:18; 1912:77. U. H. Agr. Dept. Annual Report 1927:32.

**BRUSSELS SPROUTS** Although most of the local demand for brussels sprouts (*Brassica oleracea semmifera*) is met by importations from California, small amounts aggregating an acre or two are produced here. This plant is a close relative of the cabbage and requires about the same climatic conditions, such as are found in the cooler uplands at 3,000 to 4,000 feet elevation.

See also "Truck Crops."

**BUCKWHEAT** A small test planting of buckwheat (*Fagopyrum esculentum*) was made by the Hawaii Experiment Station in 1914 to see something of the possibilities of producing this plant in Hawaii, and another trial was made in 1927 at the University Farm. It is normally a temperate zone crop but in both instances seemed to grow well here, and yielded at a moderately good rate. As a rotation crop it may have some possibilities here, for

it is valuable as a feed for poultry, and as forage for dairy cattle, as well. The flowers make excellent bee pasturage. Ref.—Haw. Exp. Sta. Annual Report 1914:40. U. H. Agr. Dept. Annual Report 1927:32.

**BUFFALO GRASS** Buffalo grass (*Stenotaphrum secundatum*) grows extensively at the lower altitudes, but is not regarded by livestock men as having great value for pasturage. It is used for lawns in shady locations where manienie (Bermuda) grass does not do well. Ref.—Haw. Exp. Sta. Bul. 65:49, 1933.

**BURDOCK** Burdock (*Arctium Lappa*), called by the Japanese "gobo," is a large-leaved plant which produces a long, fleshy tap-root, from one to four feet in length. Although the plant is normally biennial, it is usually grown as an annual so that the root may not become too long and too tough. In about ten months the root size desired by the market is attained. The root is boiled to make it edible. It somewhat takes the place of salsify, or oyster plant, in consumption demand.

The market demand for this root is limited and the production is small, some 30 acres being devoted to it, mostly in the upper portions of the valleys near Honolulu.

See also "Truck Crops."

**BUTTERBUR** Small quantities of this Japanese plant (*Petasites japonica*) are grown for market on the Island of Hawaii near the Kilauea Volcano. It is a perennial herb<sup>28</sup> with large leaves, the petioles of which are one to three feet long and very succulent, and used in soup by the Japanese.

**CABBAGE** Head cabbage (*Brassica oleracea capitata*) thrives very well in the cooler uplands of these Islands. The history of its cultivation here runs back to the early part of the nineteenth century, Marin recording it in his diary that among many other things he had planted "cabbages." In the gardens at lower elevations there has been a limited amount of production of this crop, but always under some handicaps due to insects and diseases.

<sup>28</sup>Haw. Exp. Sta. Bul. 60, p. 4, 1929.

In spite of this, however, production during the whaling period was large enough not only to take care of all local demand but to provide some surplus for exportation, as well. In 1850, for instance, some 1600 heads were shipped to California.

Cabbage production later suffered the same fate that befell the potato in Hawaii: California reversed the trend of shipments, sending her own crops to Hawaii instead of importing from Hawaii, and as a consequence Hawaiian production of certain commodities almost ceased for a good many years. Some twenty years ago, however, war conditions threatened local food supplies and farmers began producing such crops as cabbage, potatoes and others.

Imports of cabbage from the mainland are now almost negligible in comparison with the amount of local production, practically all consumption demand here being met by producers on Maui (Kula District) and Hawaii (Waimea and Volcano districts). Some 350 acres are devoted to this crop, the yield of which is between  $2\frac{1}{2}$  and 3 millions of pounds per year.

Insects and disease present serious difficulties, but probably not materially worse than in other cabbage producing regions.

An important problem confronting our producers has been the profitable marketing of this crop, but the situation is slowly improving as better grading and packaging methods are adopted under the guidance of the Agricultural Extension Service and of the Inter-Island Steamship Co., both of which agencies are doing much to help the farmers.

For a detailed account of good cultivation and marketing practices, consult the Krauss bulletin on Vegetable Production.<sup>1</sup>

**CACAO** Cacao (*Theobroma cacao*), the source of commercial cocoa, is a tree which grows only in tropical regions where rainfall, soil and climate are suitable. There are a few trees growing in Hawaii, the first introduction having been by Dr. Hillebrand about 1850. Sev-

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<sup>1</sup>Agr. Ext. Bul. 16, pp. 72-78.



eral small plantings near Hilo in the latter part of the nineteenth century aroused some interest,<sup>2</sup> but the cultivation of this plant did not develop into proportions of an industry.

These plantings, however, were a sufficient indication that conditions here were favorable, and accordingly the Hawaii Experiment Station in 1905 planted about three acres on a trial basis at Hilo, with the help of the Hilo Boarding School. Although lack of funds caused the abandonment of the project after a year or two, nevertheless the trees continued to grow and some are still there. The manager of the Hilo Sugar Co. planted cacao on his home premises at about the same time and it has done well.

Dislocation of world shipping during the World War caused an abnormally high price to be placed on many commodities, cocoa among them. This served to revive interest here in the possibilities of establishing cacao plantations. The interest was sufficiently keen to prompt the 1917 Legislature to request a statement from the Hawaii Experiment Station concerning the matter. Prospects for Hawaii were outlined as follows:<sup>3</sup>

"The tree begins to bear fruit about the fourth year after planting, and increases in production for several years. The yield of an established cacao plantation runs from 300 to 600 pounds per acre. The present high prices are not likely to continue, and for calculating returns, \$10.00 to \$14.00 per hundredweight would be as high as it would be safe to expect, which would make the gross receipts per acre run from \$30.00 to \$84.00 per year.

"As curing cacao is a process which does not require elaborate machinery or expensive equipment, the crop in this respect is well adapted to the use of small growers who may be quite widely separated. In addition the beans, when cured, are not a highly perishable product. This makes it possible to grow cacao on comparatively cheap lands at considerable distances from the world's markets and with the cheap labor so prevalent in most tropical countries. Hawaii, therefore, would have to

<sup>2</sup>See enthusiastic remarks of E. C. Crick in *Planters Monthly* Vol. X, p. 249 (1891), also of D. H. Hitchcock in Vol. XII, p. 105 (1893); the latter had a plantation of 1500 trees.

<sup>3</sup>Haw. Exp. Sta. Annual Report 1917:22.

meet strong competition in marketing the raw product. By reason of its nearness to markets and its good transportation facilities, Hawaii could counterbalance this disadvantage by entering the field of manufacture—a thing not yet attempted generally by countries far from the consumer.

“The data in hand indicate that any attempts to establish cacao growing as an industry in Hawaii should be confined to localities near sea level, and only those sheltered places which are warm and moist are to be considered. Sheltered spots in Hilo and Puna, in general, offer the best locations for further trials. The Hana coast of Maui presents some advantages.”

Ref.—Haw. Exp. Sta. Annual Reports 1904:381; 1905:59; 1917: 21-23. Haw. For. Agr. 1913:158-160.

**CACTUS** Several species of cactus produce fruits which are edible. The common panini (*Opuntia megacantha*) which grows in nearly all dry and uncultivated areas throughout the Territory has an abundance of handsome, red fruits usually called cactus pears, or tuna.<sup>4</sup> Abundant as this fruit is in Hawaii, it is but rarely eaten by people, and is of practically no economic value at present.

This is not true, however, of the cactus plant itself for in many localities its spiny “leaves” (really stems) are eaten by cattle and in some districts constitute a large part of their total diet. A spineless species has been introduced in some of the pastures, but the cattle destroy the plants before they can become well established.

In Mexico, the juice of cactus “leaves” is pressed out and mixed with whitewash to make the latter adhere better to wood surfaces.<sup>5</sup> It is said to be useful for this.

The night-blooming cereus sometimes sets fruits which are delicious to eat. By hand pollination one may produce an abundance of fruits, but at present there is no market demand for them.

**CALAMONDIN** See “Chinese Orange.”

<sup>4</sup>This is the Mexican name for the cactus pear, which is very extensively used as food in Mexico, especially by the poor people.

<sup>5</sup>Haw. For. Agr. 1912:195.

**CALCIUM CITRATE** A by-product of the pineapple canning industry.

See "Pineapple."

**CAMPHOR** The camphor tree (*Cinnamomum camphora*), a member of the laurel family and related to the avocado, is grown in Hawaii chiefly as an ornamental, having been introduced in 1894. The camphor of commerce is extracted from it, but no such use is made of the trees growing here.

Ref.—Haw. Exp. Sta. Annual Report 1916:20; Kuck and Tongg, The Tropical Garden, p. 97. Prior to 1894 the Planters Monthly (H.S.P.A.) urged the planting of camphor: See Vol. V, p. 71 (1886); IX, 238; X, 221; XI, 67 (1892).

**CANAIGRE** Canaigre, or tanners' dock (*Rumex hymenosepalus*), came into great prominence in southwestern United States and Florida in the 1890's as an unusually rich source of tannin for use in the leather industry. The plant, a native of California and related to the common rhubarb, produces a greatly enlarged root which is the chief repository of the tannin. It was anticipated that the demand for this product from the dye-stuff industry would stimulate a very extensive planting of this dock.

In 1895 the widespread interest in canaigre made itself felt in Hawaii. The Planters Monthly<sup>6</sup> urged that it be tried here, as a means of diversifying industry, for climatic and soil conditions seemed good and the market outlook very encouraging. In that same year, Commissioner of Agriculture Marsden announced that he was importing a quantity of seed of this plant for trial. It was expected that the cultivation of this crop in Hawaii would "utilize much land hitherto deemed of little value."<sup>7</sup>

As a special incentive to the establishment of the proposed new industry, the government provided tax exemption for producers of canaigre, the exemption extending to all lands, buildings and tools used for the purpose.<sup>8</sup> Import duties on planting materials, also, were to be waived.

<sup>6</sup>Organ of the H.S.P.A., Vol. XIV, pp. 492-494, 1895. See, also, Vol. XV, p. 233; XVI, p. 527.

<sup>7</sup>Thrum's Annual 1895, p. 137.

<sup>8</sup>Act 7, Session Laws of 1895.

No developments of commercial importance resulted from these efforts, however. The canaigre apparently did not establish itself in the wild state, as it is not reported by botanists in their collections.<sup>9</sup>

**CANEC** See "Bagasse."

**CANNA** The edible canna (*Canna edulis*) is an introduction from Australia where it is a plant of some economic importance for the starch content of its fleshy root-stocks. The plant grows upright, about 4 to 8 feet tall, sending up many stems from a single root, somewhat as does sugar cane, requiring 4 to 6 months to reach the stage of first blossoming. Growth of the root system continues after this, however, and harvesting need not take place until 10 to 24 months after planting.

The edible canna is not exacting in its soil and climatic requirements, for experimental plantings indicate that it will do well at any altitude from sea-level to 2,700 feet. Its best growth, however, is at elevations less than 1,500 feet and in good, loamy soil with an abundance of moisture. In short, its requirements are about the same as those of sugar cane, except that its upper range in elevation is higher.

This crop plant seems remarkably free from attacks by insect pests and diseases.

Typical yields of roots have varied from 7 tons per acre after 9 months' growth in the Glenwood (Hawaii) district to 28 tons after 12 months' growth in the Wahiawa region of Oahu, and 34 tons in the same growing period in Honolulu; an average yield may be said to be 18 to 20 tons per acre in 8 to 10 months, in any favorable location.

This plant was introduced into Hawaii in the 1890's and planted occasionally in gardens for food purposes. The cooked corms are not as good to eat, however, as potatoes or taro and the canna never gained much headway as a food crop.

In 1915 Judge J. A. Matthewman brought it to the attention of the Hawaii Experiment Station as a useful crop for the war emergency period and experiments were be-

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<sup>9</sup>According to Dr. Harold St. John.

gun soon after to ascertain the essential facts concerning its cultivation.

Attention soon shifted to the possibility of developing a starch manufacturing industry on this crop, for the Experiment Station's work on tree-fern starch was not progressing as favorably as had been expected and the edible canna seemed to offer better prospects. Experiments in starch manufacture were carried on for several years on a small scale and by 1922 the findings seemed sufficiently encouraging to warrant the establishment of an industry. A corporation was formed and a small factory was built in the Waimea district of Hawaii. Commercial plantings were made, at first cautiously but gradually over more area until in 1927 a total of about 75 acres was under this crop.

Between mechanical difficulties in the factory and financial troubles in the corporation the industry did not move forward smoothly and finally came to an end when the company was forced into receivership.

Notwithstanding this unfortunate experience, it is believed by several who are acquainted with the facts that the manufacture of edible canna starch does offer good possibilities for the development of a small but important industry in Hawaii. The crop could be grown well on any of the marginal sugar cane lands which have been forced out of use by the quota system of sugar production; planting and cultivation practices would not be greatly different from present plantation techniques. Harvesting the tubers and manufacture of the starch would require new machinery, but the returns should be large enough to warrant the investment.

An important and valuable feature of such an industry would be its usefulness in time of emergency as a source of food for the people of Hawaii. Certain by-products, as the tops and the factory refuse, would be useful as feed for livestock.

See, also, "Starch."

Ref.—Haw. Exp. Sta. Bul. No. 54 (1924), No. 56 (1927) and No. 57 (1928); also, Annual Report 1936:21.

**CANTALOUPE** The cantaloupe (*Cucumis Melo cantalupensis*) is one of the most popular of all the melons



of commerce and is consumed in Hawaii in larger quantities than it is produced. Importations from California in the summer and fall months are relatively heavy, compared with the amounts produced here. Local producers, however, are able to place good cantaloupes in the market during the winter and spring months because of more favorable growing conditions here. If by a modification of existing quarantine restrictions Hawaii should ever be able to ship this product to the mainland in the winter and spring, a good opportunity would be presented for developing an industry of considerable importance.

Cantaloupe production in Hawaii now occupies only about 50 acres.

See "Melons," also "Truck Crops."

Ref.—U. of H. Agr. Ext. Bul. 16:79, 1932.

**CARAMBOLA** The carambola (*Averrhoa carambola*) is of Asiatic origin and was brought into Hawaii many years ago. Its fruits are oddly shaped, about the size and color of a lemon but with five conspicuous flanges or wings extending longitudinally from stem to tip. It is this feature which makes the name "starfruit" appropriate, for the cross-section view is distinctly star-shaped. The pulp is juicy and good to eat, especially that of the sweet variety. The fruit is used to a limited extent in the making of jam and jelly, and in the immature stage is useful for pickles.

Although the carambola has been in Hawaii more than a half century it has not made much of a place for itself in a commercial way, being cultivated only to a very limited extent and appearing in the markets only as a specialty fruit, used more by the Chinese than by others.

Ref.—Haw. Exp. Sta. Bul. 77:17-18 (uses of carambola). Haw. For. Agr. 1905:86-87; 1917:304-306 (V. MacCaughy).

**CARDAMOM** The seed of *Elleteria cardamomum* is known in commerce as cardamom. The plant is a relative of the gingers and is produced commercially in India and Hindustan, which supply most of the seed imported into the United States. A move made in 1883 to establish production in Hawaii was not successful.

Ref.—Planters Monthly II, 266, 1883.

**CARISSA** The carissa, or Natal plum (*Carissa Carandas*)<sup>10</sup> was introduced into Hawaii from South Africa in 1905 by the U. S. Department of Agriculture. It is a shrub, with glossy foliage and forbidding spines, the fruit being about the size of a small plum and of a beautiful red color. When cooked into a sauce it resembles cranberry; it is useful for jam and jelly making, as well.

The four original plants have been multiplied into thousands by the work of the Hawaii Experiment Station and the carissa is now of moderately common occurrence in gardens as a hedge plant and ornamental shrub. Although it seems to offer some promise for commercial exploitation it is not cultivated outside of gardens in Hawaii at the present time.

Ref.—Haw. Exp. Sta. Annual Report 1910:38.

**CAROB** This hardy tree (*Ceratonia siliqua*), common in the Mediterranean region, produces pods which are very nutritious and therefore valuable as feed for livestock. It was introduced into Hawaii over thirty-five years ago, and in 1921 the Hawaii Experiment Station obtained additional seed from California where the tree is grown in many gardens. While the carob tree grows well under Hawaiian conditions, there are few specimens here in spite of past efforts to establish it in these Islands.

Probably its value is no greater than that of our common algaroba, which also has excellent worth as a source of feed for livestock. It is doubtful, in fact, that the carob would grow in all locations where the algaroba does, and therefore it would seem that the better of the two trees has established itself here.

Ref.—Haw. Exp. Sta. Annual Report 1921:20.

**CARPET GRASS** Carpet grass (*Axonopus compressus*) spreads by runners and forms a dense sod which crowds out most other grasses. It provides only moderately good pasturage. It is very widely distributed on all islands.

Ref.—Haw. Exp. Sta. Bul. 65:10, 1933.

**CARROT** The carrot (*Daucus carota*), long a food of

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<sup>10</sup>Also, *Carissa grandiflora*.

western peoples, is in steady demand here and is produced in limited quantities by market gardeners as well as in home gardens. A recent survey of crops showed about 75 acres of this commodity in the spring and early summer months, exclusive of the small backyard gardens. Several varieties do particularly well in these Islands.

Shipments of carrots from the mainland were about 210,000 pounds in the first quarter of 1936. If this is representative of the entire year, it is evident that local producers are falling far short of meeting the existing demand, for it is estimated that a typical year's production here is a little over 500,000 pounds, compared to perhaps 800,000 pounds imported.

See also "Truck Crops."

**CASHEW NUT** The crescent-shaped cashew nut (*Anacardium occidentale*) has become very familiar in the American market in the last decade or two, importations into the United States having been over 14,000,000 pounds in 1934 and nearly 18,000,000 in 1935. It is a tropical tree, related to the mango, and thrives very well in Hawaii. The nut of commerce is the edible kernel produced within a hard outer shell which is borne at the end of a small fruit resembling a miniature mango. When roasted, the nut is considered exceptionally delicious and is much in demand. The gum surrounding the kernel is somewhat poisonous.

The cashew tree was introduced into Hawaii from the West Indies a good many years ago but, until very recently, was known to but few people and was only sparingly planted in gardens for ornamental purposes rather than for its nuts. A few years ago Maunawili Ranch on windward Oahu planted about 180 acres as an experiment in forestry. These trees are thriving well and are shading out the guava bushes which are especially abundant in that locality. Although not planted for nut production purposes, this large stand of trees will soon be at the heavy bearing age and may prove to have a considerable economic value apart from forestry considerations.

The Hawaii Experiment Station has some trees growing on its Kona lands (Annual Report 1936, p. 94).

**CASSAVA** Cassava, or manioc (*Manihot utilissima*) is a tropical plant with greatly swollen roots which are an excellent source of starch (tapioca of commerce) and are used, also, as feed for livestock. It has been cultivated in Hawaii for many years and used by the Hawaiians in making starch (pia<sup>11</sup>) by their simple, if somewhat primitive, methods.

From 1916 to 1928 both the Hawaii Experiment Station and the University Farm (then separate<sup>12</sup>) conducted experiments in the cultivation of the cassava plant; several varieties were tried, various culture methods were compared and the values of certain fertilizers were determined. The good results obtained in these tests stimulated an increased planting of this crop by hog raisers and other livestock producers, for it was shown that cassava roots, when cooked, make excellent feed for swine and can be used in place of some expensive, imported concentrates. This trend toward more extensive growing of this crop did not continue long, however, perhaps because imported concentrates were easier to handle. Present plantings of cassava amount in the aggregate to less than 100 acres, with very little interest in the crop evident.

See also "Starch."

Ref.—U.H. Agr. Ext. Service, Agr. Notes No. 50, May 9, 1933 (culture and uses); Haw. Exp. Sta. Annual Reports 1902:322; 1905:23; 1916:24; 1917:51; 1918:48; 1919:45; 1920:27; 1921:26; 1922:8; 1924:12; 1928:14; 1936:21; U.H. Agr. Dept. Annual Reports 1919:6, 20, 26; 1920:25-28; 1922:18, 33-36. Thrum's Annual 1901:126. Haw. For. Agr. 1907:80-88 (excellent article by J. G. Smith).

**CASSIE FLOWER** See "Klu."

**CASTILLOA** See "Rubber."

**CASTOR BEAN** This plant (*Ricinus communis*) has been cultivated for many centuries in many parts of the world for the medicinally valuable oil contained in its seeds.

It seems to have been introduced into these Islands be-

<sup>11</sup>Pia is the Hawaiian word for starch whether it is made from the cassava root or other source; early Hawaiians made their pia from a native species of arrowroot (*Tacca pinnatifida*).

<sup>12</sup>Amalgamation of these was effected in 1929.

fore the beginning of the nineteenth century, but this cannot be stated with certainty. Don Marin mentions the castor bean in his journal as growing here before any of his importations.

A number of attempts were made here during the nineteenth century to grow this plant on a commercial basis, and several small plantations were started in various parts of the Islands. A notable example was the plantation of C. Koelling in Heeia (windward Oahu) which was maintained as a commercial undertaking for over twenty years. Other plantings were tried in Kona. The World War caused a sharp rise in the price of castor oil and stimulated more planting, but no concerted effort was made in Hawaii to revive the industry.

The plant requires good soil and at least a moderate amount of rainfall. It will grow on poor lands, but would not pay commercially.

The crop is not a very remunerative one to farmers. One to two tons of harvested beans per acre per year seem to be about the usual yield, for the seeds are relatively light and it takes a good many to make a ton. The explosiveness of the pod scatters the seeds and makes harvesting difficult. The extraction of the oil is, also, a difficult process and there are no facilities for doing it in the Territory. This means, of course, that the beans have to be exported, and the market price is scarcely high enough to arouse much interest.

Ref.—Haw. Agr. Exp. Sta. Press Bull. 2; Annual Rep. 1902:322; 1903:404; Thrum's Annual 1893:107; 1904:63; Planters Monthly XI, 476 (1892).

**CAULIFLOWER** Cauliflower (*Brassica oleracea botrytis*) is the compact flower head of a plant closely related to the cabbage and is consumed in much larger quantities than its relative, broccoli. Its production here is not very extensive, however, for it requires cool weather for the formation of firm heads. In the Kula district of Maui, and Waimea, Hawaii, where cabbage does well, truck growers produce some cauliflower, perhaps a total of 15 or 20 acres. Imports of this vegetable from California amount to nearly a half million pounds per year,



while local production provides only about 30,000 to 50,000 pounds.

Ref.—U. of H. Agr. Ext. Bul. 16:78, 1932.

**CAYENNE BERRY** See "Surinam Cherry."

**CEARA RUBBER** See "Rubber."

**CELERY** Although Hawaii consumes over a million pounds of celery (*Apium graveolens*) per year almost none is produced here, a few hundred pounds per year coming into the Honolulu market from Maui and Kauai.<sup>13</sup> Celery seems to require a cool climate and a certain type of soil not commonly occurring in Hawaii. As a result, this may be one of the truck crops which it is advantageous to import from outside rather than to grow here.

**CELLULOSE** See "Bagasse."

**CHARD** See "Swisschard."

**CHAULMOOGRA** Chaulmoogra oil, used for many centuries in the Orient in the treatment of leprosy, is extracted from the seeds of several Asiatic trees, chiefly *Hydnocarpus anthelminticus*, also *Taraktogenos kurzii*, and others.

Because of the great local interest in this oil in the 1920's, the Board of Agriculture and Forestry obtained a supply of seeds of the first named species from Siam, through the help of J. F. Rock, and planted about 2,500 seedlings in the Waiahole Forest Reserve (Oahu) in 1921 to 1923. The trees grew well and found the new environment favorable. The first fruits were produced in 1929 and a moderate production has been noted each year since then.

A less extensive planting of the second species was made in the same region in 1922 to 1924, the first fruiting occurring in 1930.

The fruits are large, each with about 30 seeds the size of a peanut packed neatly inside; the oil is contained in these seeds.

Thus far no effort has been made to extract the chaul-

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<sup>13</sup>Dr. Krauss believes that interest in the production of celery here is increasing and that it is one of the promising crops for local farmers.

moogra oil, nor to test it in comparison with the Asiatic product once imported here in considerable quantities. The use of this oil in the treatment of leprosy has been all but discontinued in Hawaii.

Ref.—Haw. For. Agr. 1930:105 (C. S. Judd).

**CHAYOTE** The chayote (*Sechium edule*) is a relative of the squash and cucumber and is a comparatively recent introduction from Mexico. It is a climbing vine and produces an abundance of pear-shaped fruits which are succulent and tasty when cooked, resembling in flavor and consistency the summer squash.

It is but rarely cultivated in Hawaii, but deserves much more attention in spite of the fact that it is sometimes attacked by the melon fly. It grows wild in certain forest areas, as Hamakua, Olaa and Kona.

Ref.—U. H. Agr. Ext. Bul. 16:86, 1932; Haw. Exp. Sta. Annual Report 1926:14.

**CHERIMOYA** The cherimoya (*Annona cherimola*) was one of the many introductions made by Marin sometime prior to 1813. Since then it has been planted sparingly in home gardens, but never on a commercial scale, for the fruit is somewhat exotic both in appearance and flavor and there seems to have been very little demand for it. As a full grown tree it is not particularly ornamental, so that from no point of view has there been any great incentive to general planting.

The Royal Hawaiian Agricultural Society in the 1850's used to mention the cherimoya occasionally as a desirable fruit tree worthy of more exploitation in Hawaii, and in more recent years the Hawaii Experiment Station has given a little attention to it horticulturally, but it still remains a novelty and rarity in home gardens, with the average person wholly unaware of its existence.

The fruit is difficult to eat, even when one has learned to like its flavor. Probably the only commercial use to which it might be put would be by expressing and canning the juice for blending with other fruit juices in punches and cocktails.

See, also, "Custard Apple," "Sour Sop," and "Sweet Sop."

**CHERRY** This temperate zone fruit (*Prunus Cerasus*) is but rarely produced in Hawaii. In the higher uplands, at elevations above 5,000 feet, there are a few trees here and there, to a total of one or two acres, but cherry production offers no commercial possibilities worthy of note.

**CHICKENS** See "Poultry."

**CHINESE CABBAGE** Chinese cabbage (*Brassica ke-tsai*) is different from the common head cabbage, being of Asiatic origin while the other is from Europe. The Chinese species has a number of varieties, some of which form compact heads but the majority are loose, non-heading.

This cabbage grows best in the cool upland regions where the head cabbage also thrives, the Kula district of Maui and the Waimea district of Hawaii producing most of the crop for this Territory. The area devoted to it is perhaps about 70 acres, exclusive of small plantings in many vegetable gardens.

See also "Cabbage" and "Truck Crops."

**CHINESE DATE** See "Jujube."

**CHINESE ORANGE** The Chinese orange or calamondin (*Citrus japonica hazara*) is more frequently grown as an ornamental in Hawaii than for its fruits, which are small and sour.

See also "Orange."

**CHINESE PEA** This edible podded pea (*Pisum sativum saccharatum*), usually known locally as the "Chinese pea," is closely related to the common garden pea but is eaten pod and all in the immature stage, while in the other only the seed is used. The Chinese pea is of Asiatic origin and was introduced into Hawaii by the Chinese for their own use, but it has proven to be so popular with other racial groups that its consumption is becoming general. Cultivation is not yet, however, very extensive, the total acreage now being about 20 acres.

See also "Beans," "Pea," and "Truck Crops."

Ref.—Haw. Exp. Sta. Bul. 60:39, 1929.

**CHIVES** Chives (*Allium Schoenoprasum*) is a perennial closely related to the commercial onion, but it is the leaves that are used in this case and not the bulbous root. The leaves resemble onion leaves but are shorter and more slender. They are used for flavoring vegetable dishes, especially by the Chinese.

Production in Hawaii is very limited.

See also "Truck Crops."

**CHRYSANTHEMUM** Young plants of *Chrysanthemum coronarium* are used by the Chinese and Japanese as greens. Two varieties are cultivated in Hawaii, but only in very small amounts, for the market demand is limited.

Several varieties of the common garden species (*Chrysanthemum hortorum*) are grown abundantly by market gardeners. See "Floriculture."

See, also, "Pyrethrum."

**CINCHONA** Quinine, a drug commonly used in the treatment of malaria, is extracted from the bark of several species of tropical trees belonging to the genus *Cinchona*, notably *C. succirubra* and *C. officinalis*. This discovery of quinine and its medicinal value, made in 1639, aroused much interest in the growing of the trees in various tropical countries. At first known only in South America, they were introduced into Netherlands India and a lucrative industry was established there in the nineteenth century.

The first introduction of the cinchona into Hawaii seems to have been in 1876 when Captain Makee planted a few trees at Ulupalakua (Maui).<sup>14</sup> In 1887 some samples of the bark were tested and found to be quite as good as the product of other countries.

A much more ambitious move toward the establishment of a cinchona industry here was made by W. H. Purvis in 1883, when he paid a visit to India and Ceylon to obtain a quantity of seed and first-hand information about cultural practices. On his return he planted 16,000 seedlings on the slopes of Maunakea, above Kukuiahae (Hawaii),

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<sup>14</sup>W. J. Forsyth reports having inspected these trees in 1888 when they were twelve years old. *Planters Monthly* VII, 15 (1888).

and a year later added more by importing seed from South America. In a report<sup>15</sup> on his work in 1886 he indicated great enthusiasm for the prospective industry, apparently considering well invested the \$3,500 which he had spent in this foundational work. It was suggested in 1884 that the Hawaiian government ought to give Mr. Purvis a prize for this important service,<sup>16</sup> but his only reward seems to have been the satisfaction of public esteem. The *Planters Monthly* declared editorially,<sup>17</sup> apropos Purvis' efforts, that "one man who will demonstrate the feasibility of establishing a new industry is doing more good and is worth more to the country than a syndicate of capitalists and a Government House full of politicians." Those are strong words to come from the organ of the sugar planters!

The Purvis plantings grew well and in due time samples of bark were sent to London for analysis. The reports indicated that the Hawaiian bark was an excellent source of quinine, especially the species *succirubra*, and this seemed to confirm the general idea that there were good prospects for the development of an important new industry here, for this drug was then commanding a very high price.

Within a few years, however, commercial extraction of quinine in Netherlands India was developed to such large proportions that the price for the commodity dropped to a relatively low figure, making the production here seem far less attractive. No other plantations had been developed in these Islands, but Purvis maintained his plantings in spite of falling prices, until it appeared to be hopeless. He made no commercial shipments and after some years abandoned the little plantation.

The trees are still thriving, however, and seem to have established themselves as well as in their original home environment. Some natural dissemination by seed is taking place, for seedlings are to be found a half mile or more away from the original trees.

In 1919 the Hawaii Experiment Station introduced

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<sup>15</sup>*Planters Monthly* V, 111 (1886); see, also, Vol. II, 259 (1883).

<sup>16</sup>The suggestion was made by W. B. Oleson (*Planters Monthly* III, 593).

<sup>17</sup>Vol. V, 124 (1886).



some additional varieties of Cinchona, believing that even at prices then prevailing there might be some attractive possibilities in commercial production of this drug. No important results followed this effort, and Cinchona joined the company of those other might-have-been industries.

The Dutch monopoly of this industry seems now to be threatened by recent developments in Formosa and the Philippine Islands.<sup>18</sup> In Formosa the Japanese are undertaking to develop an industry sufficient at least for their own national needs, while a similar movement is under way in the Philippines.

Ref.—Thrum's Annual 1899:129; Haw. Exp. Sta. Annual Report 1919:38; Haw. For. Agr. 1913:196. Also, references cited above in Planters Monthly.

**CINNAMON** The cinnamon tree (*Cinnamomum zeylanicum*) is a member of the laurel family and related to the avocado. Its bark is used for the making of commercial cinnamon. Although this tropical tree was introduced into Hawaii many years ago it has not become widely planted, occurring only sparingly in gardens as an ornamental.

**CITRIC ACID** A by-product of the pineapple canning industry.

See "Pineapple."

**CITRON** The citron (*Citrus Medica*) is grown in Hawaii chiefly as an ornamental. Its fruits have an exceptionally thick rind which is made into the citron of commerce by a preserving process.

See also "Citrus Fruits."

**CITRUS FRUITS** Oranges, lemons, limes, grapefruit and citrons are commonly grouped together as citrus fruits. They are among the most valuable and important fruits known to humanity, and they are to be found in nearly all markets of the world, for countries which are not situated favorably for producing these fruits almost invariably import them. The commerce in citrus fruits, if it could be computed, would reach a stupendously large total. In

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<sup>18</sup>Far Eastern Survey (Institute Pacific Relations), New York, Vol. V, No. 25, p. 276, Dec. 19, 1936.

the United States alone the production in 1934 was over 58,000,000 boxes.

This interesting group of fruits was unrepresented in Hawaii before the arrival of western civilization, but in the past 150 years several kinds have been introduced and are successfully established. None, however, have become of great commercial importance here.

The species which are more or less well known in this Territory are the following, each discussed briefly under its own heading:

Citron (*Citrus Medica*)

Grapefruit (also, Pomelo and Shaddock)

Kumquat (*Fortunella japonica*)

Lemon (*Citrus limonia*)

Lime (*Citrus aurantifolia*)

Orange—Chinese Orange (*Citrus japonica hazara*)

Mandarin Orange (*Citrus nobilis*)

Ordinary Orange (*Citrus aurantium*)

**CLOVER** See "Hubam Clover," "Sweet Clover."

**CLOVES** The cloves of commerce are the dried flower buds of *Eugenia aromatica*, a tropical tree cultivated in Zanzibar, Madagascar, Sumatra and other islands of the Indian Ocean. Dr. H. L. Lyon has at various times obtained seeds for trial in Hawaii, but thus far has not been successful in his effort to germinate them.<sup>19</sup> Interest in this as a possible crop for Hawaii was in evidence last century, but no serious effort was made to introduce the plant.<sup>20</sup>

**COCOA** See "Cacao."

**COCAINE** Cocaine, a useful drug of commerce, is made from a tropical plant (*Erithroxylon coca*) which grows well in Hawaii. No effort has been made here to develop an industry for the manufacture of this drug, although there was a brief interest shown in such a possibility in 1892.<sup>21</sup>

**COCONUT** The coconut (*Cocos nucifera*) was prob-

<sup>19</sup>Verbal statement to the author.

<sup>20</sup>Planters Monthly Vol. III, p. 524 (1884), and XII, p. 216 (1893).

<sup>21</sup>Planters Monthly Vol. XI, p. 60-67, 1892.

ably one of the few food plants growing in these Islands before the coming of the original Polynesian immigrants. If it did not precede them, it was introduced by them at an early date, for it has been present here for a very long period of time. To the ancient Hawaiians it was one of the most valuable of economic plants, for it yielded food, shelter and clothing materials, and provided them with utensils, tools and trinkets. In some tropical regions there is in addition to this a considerable commercial value because of the immense market for copra, fiber and shell of the nuts. It was estimated by Barrett<sup>22</sup> in 1930 that the world crop of coconuts is about 10 billion nuts per year, with a commercial value of about \$350,000,000.

In Hawaii the coconut is important chiefly for local consumption. Several attempts have been made to develop a large industry around it, but with no great success.<sup>23</sup> High cost of labor and land makes it very difficult to compete with the Philippines and other tropical countries noted for their copra exports, and several coconut groves which have been planted here for commercial purposes now are little more than ornamental spots; one developed on Kauai by E. H. W. Broadbent yields a moderate income from sale of nuts for local consumption. A grove on Oahu has been abandoned as a commercial venture and the land subdivided for country homes. On several of the islands there are coconut groves of ancient planting which were associated with the village life of the early Hawaiians. These groves still yield an abundance of nuts as well as providing spots of rare beauty.

In 1905 Ralph Hosmer called attention to the great possibilities in the production of copra in Hawaii. His suggestion was that the many miles of unused coastal lands could be covered with coconut trees and become the source of great wealth to the Territory. While some planting of coconuts resulted, there was no immediate move to establish an industry.

In 1913 a movement was started here to develop the

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<sup>22</sup>O. W. Barrett in "World Crop Statistics," Agr. Studies No. 13, published by U. of H. in March, 1930.

<sup>23</sup>For evidences of early interest in this as a crop plant for Hawaii the reader is referred to the *Planters Monthly* (H.S.P.A.) wherein are numerous statements of interest, as in Vol. III, p. 361 (1884); X, p. 426 (1891), and others.

manufacturing of foot-mats, brushes and brooms from the short, stiff fibers (coir) of the husk which encloses the nut. An ingenious machine was invented for this, but inadequacy of capital and the prospect of higher wages here as compared with the Philippines forced a transfer of activities to the latter country. At present, however, there is a new effort being made to stimulate the manufacture of coconut fiber articles, but on a home industry basis rather than in large factories, for it is felt that in this way the wage factor may not be so serious a handicap.

In this same manner there is developing a considerable home industry in the manufacture of buttons, buckles and other novelties from the ivory-like shell of the coconut.

A new and promising possibility which is beginning to be exploited is the weaving of hats from fine fiber strips of the flower stalk; it is said that these hats resemble somewhat the so-called panama hats and have some good points not possessed by the latter.

We should mention, too, the extensive consumption of coconut ice cream, made from a blending of cow's milk and coconut milk, and other uses of locally produced coconuts as food.

The coconut oil sold in the local market is not made from locally produced coconuts, but is imported.

Although the supplying of coconuts for local consumption is not organized into a commercial industry, it is nevertheless a source of income of no small importance to some homes. The majority of homes have one or several coconut trees which not only enhance the beauty of the grounds but furnish nuts for home use on frequent occasions. In the aggregate there must be at least 100,000 trees in the Territory, yielding with varying degrees of abundance from 40 to 100 nuts per year; while some of the total crop is wasted, a great many thousands of nuts are consumed in the various ways indicated above.<sup>24</sup>

Ref.—U. of H. Agr. Studies No. 13, March, 1930; Haw. Exp. Sta. Bul. 77:19-24 (uses as food); Annual Reports 1921:19; 1922:7; Bryan, *Natural History of Hawaii* (1915), p. 235; Haw. For. Agr. 1905:348-350 (Hosmer).

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<sup>24</sup>J. M. Westgate estimated in 1932 that the commercial crop of coconuts in Hawaii amounted to about 250,000 nuts per year. In addition, there are many bearing trees the nuts of which do not enter commercial channels, as the interest in them is only for ornamental purposes.

**COFFEE** The coffee industry in Hawaii, now a hundred years old, has been only indifferently successful. In some respects the situation here is ideal for this industry—excellent climate, good soil, freedom from storms, no troubles from political instability, easy access to a huge market—but after a century of effort it has little in the way of results to show: the acreage under coffee, now about 6,000 acres, is less than it once was; in several regions coffee production has ceased altogether, as on Oahu, Maui, Kauai and several portions of Hawaii Island; the industry is deeply in debt, with almost no prospect of coming through it whole; as compared with other industries in its class, coffee production here is relatively primitive, having made little effort to apply modern science either to production, processing, or marketing. Even after a hundred years it is still uncertain what might be done for this industry if it were completely revamped and modernized.

Coffee production in this Territory began in 1825 near Honolulu, at the same time that the sugar industry had its beginning.<sup>25</sup> This first effort failed in a few years, but another and this time a successful undertaking was begun on Kauai in 1835, again both sugar and coffee being tried. At that time labor was becoming scarce, for the population of the Islands was rapidly decreasing and outside sources were not then being drawn upon; as a result, the cost of harvesting the coffee proved to be too much of a handicap, making the industry much less profitable than sugar production. Consequently, it was pushed down to a secondary position and did not receive the attention that was given to sugar. While sugar forged ahead under the stimulus of the science of mass production, coffee came to be thought of as a good crop for the "little fellow" to handle, but not worthy of attention from the big concerns. An instance of this attitude was the official report of the director of the Hawaii Experiment Station<sup>26</sup> some years later in which he declared that coffee "is a crop

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<sup>25</sup>The first planting of coffee in Hawaii was on January 21, 1813, by Don Marin, according to an entry in his journal. (Information furnished by Mr. Y. B. Goto, who is compiling a history of the coffee industry in Hawaii.)

<sup>26</sup>Annual Report for 1901, p. 367.



especially suited to the small farmer and the small investor."

When the Kauai effort failed the trees were uprooted, but the production of coffee did not cease in the Islands, for small plantings were made in many scattered places. The fact that the coffee beans, when properly prepared for market, not only had a ready commercial value but also were of a relatively non-perishable nature made this product available to the native kings and chiefs as a medium for the commoners to use in paying taxes. Thus the industry developed into a backyard and small scale affair. Some exports of coffee were made, for the superior quality of Hawaiian coffee was recognized very early in the American market, but until the close of the century the shipments were comparatively small, considerably less than a million pounds per year.

Although developed in small units, the total was sufficient to make the coffee industry second to sugar among the commercial (plant) crops grown in the Islands, until 1862 when rice production had a boom and pushed coffee into third place. In the 1880's coffee reached a very low point in its history, exports almost ceasing and even the local market almost disappearing because of the inroads of cheaper coffee from America. The reciprocity treaty made with the United States in 1875 had been a great benefit to the sugar industry, for it removed the necessity of paying the American tariff, but it was a serious blow to the already waning coffee industry, for it removed the Hawaiian tariff on coffee imports which had protected local producers against foreign competitors, and American shippers began sending in cheap grades to flood this market.

In the 90's, however, the world market offered higher prices for coffee and this caused a sudden but not well considered expansion of the nearly dormant industry in these Islands.<sup>27</sup> Hundreds of thousands of dollars were sunk in the new coffee ventures in many locations, some of

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<sup>27</sup>Just prior to this, in 1887, W. H. Purvis had introduced the Liberian variety of coffee which produced larger beans of better flavor than the varieties previously cultivated, but it did not find wide favor because of its tendency toward scanty bearing. It was the Guatemalan variety (*Coffea arabica*) on which this new expansion of planting was based.

which were quite unsuited for the purpose. Jared Smith, writing in 1901,<sup>28</sup> declared that "probably \$10,000,000 has been sunk in unprofitable coffee cultivation in these Islands during the past ten years." As a result of this expansion the coffee industry again rose in 1899 to second place, above rice, but held that position only a few years, for by 1905 the pineapple industry had begun to surpass both coffee and rice.

Meanwhile, there had been significant changes taking place in the human side of the industry. Originally begun by foreigners, the production of coffee had passed into the hands largely of Hawaiians for a half century or so, for it proved to be an easy way for them to meet their tax obligations,<sup>29</sup> and those responsible for the industrializing of agriculture here were not much interested in the industry. The boom at the end of the century, however, changed this greatly, for American, German and British operators came back into activity again when there seemed to be a prospect of developing it into something of large economic importance; it is not in Hawaiian temperament to become greatly stimulated by a boom in industry or trade. But the bubble soon burst and the new operators lost interest (as well as most everything else). The industry no longer, however, was in the hands of Hawaiians, but was taken over by Portuguese, operating on a small scale as the Hawaiians had done before them. In a few years they, too, lost heart as coffee prices went down and earnings dwindled, and Japanese began to displace them. Today, almost all coffee planters in Hawaii are Japanese who formerly were sugar plantation laborers, attracted away by the prospect of economic independence in the production of coffee.

The Hawaii Experiment Station, established in 1901 by the U. S. Department of Agriculture, was much more interested in the diversification of agriculture in the Islands than in the advancement of any industry already well established. While coffee production was an old industry, it was not well established, and, quite properly, the new station turned some of its attention in that direction. Its

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<sup>28</sup>Annual Report of Hawaii Experiment Station, p. 366, 1901.

<sup>29</sup>See "Paradox in Hawaii," pp. 134, 144.

annual reports for several years had a good deal to say about the ideal conditions in Hawaii and the desirability of expanding and modernizing the industry. It was declared<sup>30</sup> that instead of using only about 5,000 acres there were "half a million acres suitable for coffee cultivation in these Islands—enough land to support 30,000 white families." Repeatedly it was urged that the United States government levy a tariff against foreign coffee, for it was believed that, with a protection of 2½ to 5 cents per pound, Hawaii and Porto Rico could produce as much as the entire country could consume.<sup>31</sup>

By 1906 this interest seems to have subsided, for no response was in evidence to the invitation to cover a half million acres with coffee to be cultivated by 30,000 white families. Between 1906 and 1918 the Station's reports scarcely even mention coffee; then, at the latter date a little resumption of interest came to the surface again when the coffee farmers appealed for help in combating a sooty mold disease. Assistance in their problems of pruning, fertilizing and propagation began to be given a little later, after the merger of the Station with the University in 1929 made it possible through the availability of larger support. Now there is a substation in Kona, devoting a large part of its time and attention to coffee problems. By this help the coffee growers have been enabled to reduce production costs through more judicious fertilizing, effective pruning, control of diseases and pests including the rat, and in other ways.

But even these economies will probably not be sufficient to save the industry; it will require some heroic measures to keep it from going on the rocks.

To survive and amount to anything, the coffee industry has five very urgent needs:

1. Relief from present debt burdens.
2. Drastic reduction of land values and taxes.
3. Application of science to production, harvesting and processing practices.
4. Better marketing methods.
5. Organization of producers into cooperatives or corporations.

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<sup>30</sup>Annual Report 1902, p. 313.

<sup>31</sup>Annual Report 1901, p. 369.

Let us consider each of these five, in turn. The debt situation is practically hopeless. Even federal agents of the New Deal which have been trying to do so much of late toward extricating improvident farmers from debt declare that they see little or no prospect of relief for our coffee growers in Kona. Their debts are so large from long accumulation that neither current nor prospective earnings are adequate to liquidate them, and federal aid is not available because the farmers do not own the land on which they operate. Either the majority of present producers will have to be closed out and the farms taken over by the creditors in settlement of the debts, or the debts will have to be greatly scaled down and some long term plan adopted for the liquidation of the remainder. Of the two alternatives, the latter would seem the more sensible.

Second is the matter of land values. Considered over a long period of years, with short ups and long downs in market prices, coffee in Hawaii has yielded small returns, by no means justifying the usual rental rates. Since taxation is correlated to rental rates, it, also, is higher than the industry can stand. As was necessary in the great farming areas of the mainland a few years ago, a drastic downward revision of land values is in order in the coffee districts of Hawaii.

The third item of need has already been touched upon. The Experiment Station is beginning to do that which ought to have been done long ago—to make production, harvesting<sup>32</sup> and processing practices as efficient as science can make them, at a minimum of cost. Compared with the sugar and pineapple industries, coffee production is still in a primitive state of development.

The fourth item, marketing, needs reorganization. Most of the coffee produced in Hawaii is sold in "parchment" form, delivered by the farmer to a neighborhood store-keeper in partial payment of a long standing debt for food

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<sup>32</sup>The largest single item in the total costs in the coffee industry is the harvesting. It costs more to pick the coffee than to raise it; picking represents about 58 per cent of the total cost of production. It will be impossible to reduce this item materially, so long as present harvesting methods are used, because picking is done by hand and wage rates are much higher in Hawaii than in other coffee producing countries. If all the crop were harvested in one or two pickings by mass methods, or if machine harvesting were possible, the cost could be considerably reduced.

and other supplies purchased by the farmer; the price paid for it is subject to much bargaining, with the advantage usually on the side of the storekeeper, for he is the creditor. Some (perhaps ten per cent of the crop) is "bootlegged": a producer under contract to deliver all his crop to a creditor may seize upon an opportunity to sell part of his coffee secretly to an itinerant agent, for in this way he obtains real cash instead of mere credit on an old account. This bootlegging tends to depress current prices, for the lure of cash money offsets a price cut and most producers are willing to bargain on that basis at prices below market.

There are too many middlemen, each making a living from the coffee as it goes by on the way to market. And, finally, the coffee, although admittedly superior and capable of commanding a relatively high price when sold on its own merits, is sold to general brokers for blending with other and inferior coffees from other parts of the world. If sugar cane and pineapple producers had to sell their harvest in the raw to a neighborhood storekeeper who in turn would sell it to a wholesaler who in turn would sell to a mill with several more middlemen waiting their turn to handle the product, there would be no great sugar and pineapple industries in Hawaii today. No more is coffee able to carry its present millstone and survive.

The fifth item is cooperation. Without it, the small farmer is at the mercy of ravening wolves on all sides. With it, he and his neighbors can reduce their costs both of purchasing supplies and of producing their crops and they can get more nearly the maximum returns possible from available markets for their product. The sugar and pineapple producers have gone even a step further into corporations which represent the pooling of efforts of many individuals as stockholders. Then, with cooperation between the corporations the maximum achievement becomes a reality.

If these five things could be achieved by the coffee industry it could perhaps develop into major proportions among the industries of these Islands, for the slopes on the lee side of our high mountains are better than any other place on earth for the production of coffee. This



is an assertion by many who are in position to know, among them being a federal expert<sup>33</sup> who was recently assigned to Porto Rico to solve their problems and came here first to see what Hawaii's position is in regard to coffee. There are many more thousands of good acres which could be used for this industry, if it had any prospect of success along the five lines suggested above.

It is probable, however, that these five things will not be achieved, and the industry will continue to be a minor feature in our economic structure. Returns from this crop vary greatly because of fluctuations both in market prices and in annual yields. Prices of green coffee since 1900, for example, have varied from \$0.105 to \$0.272 per pound.

The fluctuations in Hawaii's annual coffee crops is shown in the following table of exports to the mainland:

*Annual Coffee Exports to Mainland*<sup>34</sup>  
(1845 to 1935)

<i>Year</i>	<i>Pounds</i>	<i>Year</i>	<i>Pounds</i>
1845.....	248	1867.....	127,546
1846.....	1,000	1868.....	78,373
1847.....	26,243	1869.....	340,841
1848.....	58,065	1870.....	415,111
1849.....	28,231	1871.....	46,926
1850.....	208,428	1872.....	39,276
1851.....	27,190	1873.....	262,025
1852.....	134,067	1874.....	75,496
1853.....	45,496	1875.....	165,977
1854.....	87,704	1876.....	153,667
1855.....	77,616	1877.....	101,345
1856.....	63,532	1878.....	127,963
1857.....	311,807	1879.....	74,275
1858.....	64,866	1880.....	99,508
1859.....	82,528	1881.....	18,912
1860.....	48,966	1882.....	8,131
1861.....	45,366	1883.....	16,057
1862.....	146,463	1884.....	4,231
1863.....	133,171	1885.....	1,675
1864.....	50,083	1886.....	5,931
1865.....	310,799	1887.....	5,300
1866.....	93,682	1888.....	7,130

<sup>33</sup>Col. Francis J. Behr.

<sup>34</sup>Compiled from Thrum's Annual and other sources; these figures do not represent the total crop, for a considerable amount is consumed within the Territory and during the past decade the exports to foreign countries have steadily increased from a few hundred thousand pounds to over 2,500,000 pounds in 1935. The total crop in 1935 was 9,828,140 pounds, according to figures compiled by the U. H. Agricultural Extension Service.

1889.....	43,673	1913.....	2,149,875
1890.....	88,593	1914.....	4,430,722
1891.....	3,051	1915.....	3,191,274
1892.....	13,568	1916.....	2,520,364
1893.....	49,311	1917.....	1,987,035
1894.....	180,150	1918.....	3,206,202
1895.....	118,755	1919.....	6,844,841
1896.....	255,655	1920.....	2,635,635
1897.....	337,158	1921.....	3,573,521
1898.....	733,285	1922.....	4,507,511
1899.....	824,864	1923.....	3,407,759
1900.....	321,139	1924.....	2,678,882
1901.....	2,630,149	1925.....	4,965,286
1902.....	1,210,098	1926.....	3,016,466
1903.....	1,930,554	1927.....	3,152,399
1904.....	1,481,968	1928.....	6,980,346
1905.....	1,543,362	1929.....	5,151,266
1906.....	2,147,154	1930.....	8,099,206
1907.....	1,098,374	1931.....	7,658,009
1908.....	1,310,432	1932.....	6,636,656
1909.....	1,753,119	1933.....	7,759,696
1910.....	2,350,586	1934.....	4,158,135
1911.....	2,705,144	1935.....	5,399,330
1912.....	2,128,968		

Ref.—Chief among references is Bulletin 75 of the Hawaii Experiment Station, "Coffee Cultural Practices in the Kona District of Hawaii," 1935; Bul. 77:25-26 (uses of coffee); also, Haw. Exp. Sta. Annual Reports 1901:366-372; 1902:313-314; 1903:409-412; 1906:14; 1918:42; 1919:31; 1927:10; 1928:12; 1930:17, 24; 1936:10, 44-48, 93. U. of H. Agr. Studies No. 3, 1927; Crawford, "Paradox in Hawaii" (Stratford Co.) pp. 129-154, 1933; Kuykendall, "History of Hawaii" (Macmillan) pp. 319-320, 1928. Thrum's Annual 1876:46-52; 1895:63-68; 1898: 109-113 ("Coffee, the Coming Industry"); 1900:128. The Planters' Monthly (H.S.P.A.) contains many interesting articles on coffee, as Vol. X, p. 77 (1891); XI, p. 531; XIV, p. 100; XV, p. 13; XVI, p. 95, and others. Haw. Ed. Rev. Nov. 1926, p. 65 (Story of Coffee).

**COIR** See "Coconut."

**COLLARDS** Collards (*Brassica oleracea acephala*), related to the cabbage, are produced in Hawaii only to a very small extent, occurring occasionally in market gardens.

See also "Truck Crops."

**COPRA** See "Coconut."

**CORIANDER** This delicate plant (*Coriandrum sativum*) is produced in Hawaii in small quantities for use in seasoning vegetables and other dishes and sometimes for garnishing. The demand is mostly from the Oriental

peoples here, notwithstanding the fact that the plant is of European origin.

See also "Truck Crops."

**CORN** Corn (*Zea Mays*), a peculiarly American crop, found its way into the Hawaiian Islands soon after the discovery voyage of Captain Cook. The Hawaiian people, however, did not seem to value it as food and for many years therefore the only place where one would have found it growing was in the gardens of some foreigners. Letters of the early missionaries sometimes mentioned corn as one of the common garden crops,<sup>35</sup> and not infrequently the mention was occasioned by wrath at the havoc of insect pests. Yields were often very disappointing, due to the ravages of caterpillars and aphids; the corn leafhopper and mosaic disease seem to have come in later.

Production of corn was not limited for long to the home garden, however, for there were some early attempts to make it a field crop for horses and cattle; in 1853, for example, an area of 25 acres was planted to corn on Kauai, with rather poor results, while at about the same time other trials in the cooler uplands of Maui and Hawaii met with better success. It was only in such sections that corn became an important crop, and by the end of the century the total area devoted to it had increased to fully 7,000 acres, the chief centers being the Kula district of Maui and the upper portions of the Parker Ranch on Hawaii.

The maximum planting of corn was in 1919 and 1920 when the total area increased to about 10,000 acres, surpassing rice and becoming the third most extensive field crop in the Islands, surpassed only by sugar cane and pineapples. This was stimulated by the unusually high post-war prices and, of course, was a temporary situation; after the boom burst, prices came down and the acreage diminished very greatly.

The Hawaii Experiment Station began in 1903 to turn its attention to corn as a potential crop for the diversification of Hawaiian agriculture. It was Director Smith's idea<sup>36</sup> that by the introduction of new varieties and better

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<sup>35</sup>See, for example, Miss Damon's "Koamalu" in which many references to garden corn occur in letters.

<sup>36</sup>See Hawaii Experiment Station Report for 1903, pp. 392-4.

methods of cultivation it might be possible to expand this industry which in the higher areas was already about 50 years old. A few new varieties were given a trial, but other demands on the new station crowded corn off the stage for several years.

It reappeared in 1913, when the Hawaii Station reported an increasing interest in this crop on some of the sugar plantations where experience was showing that plantings in fall and winter would yield from 40 to 60 bushels per acre in the lowlands, and that was enough to more than equalize the cost of the imported product, especially as prices were again on the upswing. They did not figure on the corn leaf-hopper, however, which had gained entrance to the Islands and was becoming a very serious pest. Spraying with insecticides was too expensive and of doubtful efficacy, and parasites introduced in 1917 by the Board of Agriculture and Forestry reduced the pest only to a degree. It still continued to be ruinous in all lowland areas, but affected the higher lands very little.

Mosaic disease, also, had come in and was causing much havoc by dwarfing and stunting the growth and reducing the yield sometimes to nothing.

For a decade or more, beginning in 1917, efforts were made both by the Hawaii Experiment Station (then federal) and the University (then the College of Hawaii) to find a variety which would be resistant to the leaf-hopper and mosaic disease and would do well in the lowland areas. A large number of varieties were brought in from all over the world, but none showed any promise of success except two—a white variety from Guam and a red type from Cuba. Both stations devoted a good deal of effort to improving these and adapting them to Hawaiian needs. The local demand was for a yellow or red corn, but the white Guam prospered best here, so that crossing was resorted to in the hope of developing the perfect corn for Hawaii. Gradually, however, these efforts diminished, and finally were abandoned about 1928. Prof. Henke, who had been the leader in this field, reported in 1928 that "corn has never been grown on the University farm with any degree of success,"<sup>37</sup> while Prof.

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<sup>37</sup>U. H. Agr. Dept. Report 1928, p. 34.

Krauss complained that yields were much less than those of ten years earlier. Almost simultaneously, both stations practically abandoned further consideration of corn as a lowland crop.

Notwithstanding this, corn is grown to a limited extent here and there in the lowlands, very sporadically, and sometimes a moderately good crop is harvested. By far the best results, however, are obtained at elevations above 4,000 feet, but the total acreage today is far less than in 1920; a recent survey by the University's Agricultural Extension Service showed only about 1,700 acres in field corn in 1936, most of this on the Parker Ranch and the rest on Maui.

The experience of a century seems to indicate that corn is not a profitable crop for Hawaii and should not be attempted except when market prices are high or when an emergency cuts off normal food and feed shipments from the mainland. At elevations above 4,000 feet it may be grown successfully, provided the rainfall is adequate; in about two years out of five it is not adequate, and the crop fails.

*Sweet corn*, for table use, is of equally difficult culture in the lowland regions near Honolulu. However, a variety recently introduced from Porto Rico has done well during the past two years in experimental plantings at the Hawaii Experiment Station. The plants are vigorous, moderately free from mosaic; of the product the Station's annual report (1936, p. 25) states, "quality good, ears large, kernels sweet."

Ref.—"Koamalu" (E. M. Damon), several page references as given in index; U. H. Agr. Dept. Annual Reports 1918:2-8; 1919:7-9; 1920:8-12; 1921:9-14; 1922:13-18; 1923:8-9; 1924:8-10; 1928:34. Haw. For. Agr. 1919:40 (Henke). Haw. Exp. Sta. Ann. Reports, 1903:392-4; 1913:36, 39; 1917:51; 1918:46; 1919:44; 1920:28, 56; 1921:29; 1922:9; 1925:9; 1926:14; 1927:14; 1928:15; 1929:30.

**COTTON** King Cotton<sup>38</sup> made two noteworthy attempts to establish himself in Hawaii, but without success.

The earliest efforts at growing cotton here were in the

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<sup>38</sup>There are several species of cotton; the one most commonly grown in Hawaii is *Gossypium barbadense maritima*.



first years of the nineteenth century,<sup>39</sup> but it was on a very small scale, with nothing of a commercial nature ventured until about the time of the American Civil War. Then, because the normal intercourse with the southern states was interrupted by war operations, the northern states turned to these Islands as a possible source of cotton. An industry flourished for a few years (1863 to 1874), then languished and died when the old trade lines were reopened between the northern and southern states after the War. The maximum exports were in 1866 when a total of 22,289 pounds were shipped to the United States.

Here and there in yards and small volunteer patches some cotton continued to grow, but there was no industry. An effort was made in 1894 to 1898 to revive the industry, but with no immediate results.<sup>40</sup> At the turn of the century, however, the price of cotton began to move upward and a new wave of popular interest in this crop plant began to spread through the newly annexed Territory.

In 1902 the Hawaii Experiment Station reported a widespread desire for information about cotton culture and a considerable demand for seed. The Station imported many varieties for trial, as well as reviving the Sea Island variety that had furnished the basis of the Hawaiian industry during the Civil War years.

The Orient, both Japan and China, was beginning to use large quantities of raw cotton and the buying was chiefly from the United States. People here reasoned that it would be relatively easy for Hawaii to capture as much of the Orient business as could be met by our production capacity, for freight from the southern states to the Orient cost much more than from Hawaii, and our production costs would not be higher and might be lower.

In 1906 some samples of our various kinds of cotton fiber were sent to the U. S. Department of Agriculture for testing. Aside from the variability of the samples, which was not surprising at that stage of the development of the industry, the report came back that in tensile strength, curliness, length of fiber, and amount of lint on the seed the

<sup>39</sup>Marin stated in his diary that in 1815 he planted cotton. (See Trans. Royal Haw'n Agr. Soc. Vol. I, No. 1, p. 46.)

<sup>40</sup>Thrum's Annual 1898, pp. 57-61, "Cotton—A Possible Hawaiian Industry." See, also, Planters Monthly XIII, p. 81-85 (1894).

Hawaiian product showed some remarkable possibilities.

The best types seemed to be the Sea Island and the Caravonica, both growing as perennials in Hawaii, although it was not their habit in most other places. It was found that the best localities here for producing cotton were the protected areas on the leeward side of the Islands, from sea level to 700 or 800 feet elevation, where rainfall was moderate and ranged from 20 to 60 inches per year.

By 1909 commercial planting had begun, about 100 acres then being under production and relatively large plans reported to be in the offing.

In 1910 the acreage of cotton was about 500 acres, the largest single planting being a field of 80 acres. One of the early pioneers was the late E. C. Smith, who later became a leader in the honey industry. Leeward Oahu (Kunia, Waipahu, etc.), Makaweli on Kauai and the Kona district of Hawaii were being tried out commercially for this crop. Kona seemed finally to prove itself the best cotton district. In 1911 a Japanese hui had 500 acres, mostly of Caravonica, in Kona.

Commercial shipments of cotton began<sup>41</sup> in 1911 and continued for a few years, but only on a small scale, for the industry did not expand beyond the plantings mentioned above. The following tabulation of cotton exports shows the limited extent of this industry:

<i>Year</i>	<i>Value</i>
1911 .....	\$2,753
1912 .....	979
1913 .....	4,048
1914 .....	1,333
1915 .....	764
1916 .....	none
1917 .....	1,843

The Experiment Station, meanwhile, was continuing its work on this crop, the 1912 Report of the Director stating that it was receiving more attention than any other crop on their list, doubtless because he saw the potential importance of establishing an additional industry to stabilize the economic structure of Hawaii. In addition to variety tests, the Station was developing a technique for propagating cotton plants from cuttings, for seed propa-

<sup>41</sup>It would be more accurate to say resumed, for some shipments had been made in the 1860's, as stated above.

gation was too uncertain in the quantity of yield at harvest. E. C. Smith, a pioneer grower, had discovered that Caravonica cotton could be budded very easily, and that seemed to offer some interesting possibilities. Average yields were about a bale per acre, which was good in comparison with other cotton countries.

Pruning, also, came in for much attention, for cotton was a perennial plant here and had to be pruned to be prevented from sprawling all over and becoming unproductive. Very successful schemes for pruning were evolved.

Insect pests of several kinds were known to attack cotton, no matter what variety was grown. Cut worms, aphids and mealy bugs were always on hand, but the worst of all pests was the pink boll worm, a caterpillar which lived inside the young bolls and destroyed the fiber.

In 1910 and 1911 it was believed by Station authorities that the pink boll worm could be controlled by the simple expedient of pruning the bushes after the harvest and burning the trash, thus destroying most of the caterpillars and cocoons so that the pest would be slow in making its appearance before the next crop came on. When some planters reported that this method was not effective, the Station explained that they must prune an entire field at one time and burn the trash; if one part were cleared first and a few weeks later another part was treated, the first would become infested from the other, and so the pest would be carried along almost in full strength.

A year later, however, the Station authorities announced that the clean culture method of controlling the pink boll worm was not effective, after all. In fact, they showed a great deal of discouragement in the 1913 Report when the Agronomist said, "The pink boll worm continues its ravages, and there is little hope of any cotton industry in Hawaii until some remedy has been found for this pest. The cotton areas in the Islands are growing less instead of greater. The 50-acre field at Makaweli, on Kauai, has been uprooted since no profitable crop has been obtained in three seasons, owing to dry conditions and the boll worm. There remains still on Kauai perhaps 50 acres of cotton, in the Kona region of Hawaii per-

haps 75 acres, in the Kaneohe district of Oahu about 80 acres, and in the Waianae district possibly 30 acres."<sup>42</sup>

New horticultural quarantine orders issued by the U. S. Department of Agriculture in 1913 included cotton in countries harboring the pink boll worm. This closed the American market to us, leaving only the Orient and any possible demand which could be developed within the Territory.

After 1913, the Hawaii Experiment Station seems to have given no further attention to cotton, but a few growers in Kona persisted, nevertheless, in their efforts to develop the industry. As they were all Japanese, they were not much worried about the closing of the American market, for they could sell in Japan all that they could produce, and at a fairly good price. One group is today growing Caravonica cotton in Kona on a total area of about 100 acres.

On these fields the boll worm seems to be no great problem. Parasites kill many, and the once discarded method of burning all trash after a general pruning seems to be sufficiently effective so that the present Kona growers are able to harvest good crops most every year. One of them remarked to this writer a few years ago that he would plant 500 acres if he could obtain financial assistance.

For the small farmer this crop seems to offer some possibilities, in spite of the admittedly dismal history through which this industry has passed in the last hundred years in Hawaii. There is a considerable market within Hawaii for cotton to be used in stuffing mattresses, pillows and other similar uses. For any surplus above local needs the Orient offers a good market and it seems to be possible to produce a worth while crop, even against certain known obstacles.

It is not a highly remunerative crop. At present prices, probably \$50 to \$100 per acre would be an average return, provided proper methods are used in production. It probably is not well suited to the corporation method of large scale production, but for the small farmers operating in the lower coastal belt of Kona it might be a

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<sup>42</sup>Haw. Exp. Sta. Annual Report 1913, p. 38.

moderately profitable crop. At any rate, it will bear careful consideration before being discarded because of past failures.

Ref.—Haw. Exp. Sta. Bul. 18 (1909); Press Buls. 24, 32, 34; Annual Rep. 1902:322; 1903:407; 1906:10; 1908:15, 82; 1909:11, 69; 1910:13, 57; 1912:23, 74; 1913:38. Thrum's Annual 1909:149-152; 1911:58-67 (F. G. Krauss); 1912:91-96 (E. V. Wilcox). Haw. For. Agr. 1904:23-26 (possibilities for Hawaii); 1910:67 (very promising outlook).

**COWPEA** The cowpea (*Vigna sinensis*) is a native of Asia but has been under cultivation in the Occident for many years. First introduced into Hawaii by the Chinese for use as a food for themselves, it later was tried as a livestock feed and, also, as a soiling crop.

During a period of nearly fifteen years (1917 to 1930) the University Farm made experimental plantings of many varieties of the cowpea, in the effort to establish this crop in Hawaii. The most serious obstacle to this was the extreme susceptibility of the plant to an insect pest known as aphid, or plant louse. To control this insect by the use of sprays is too expensive in proportion to the value of the crop. Test plantings in which the aphid was eliminated, showed excellent results in producing as much as 10 to 12 tons of green fodder per acre in about two months. The plants are succulent and nutritious and much relished by livestock. But for the aphid, the cowpea might be the leading crop for dairymen in Hawaii. Of some 20 varieties tested, the Victor and Brahman proved to be the best for these Islands.

The Chinese use the green pods in the preparation of certain vegetable dishes, in much the same way as green string beans are used (see Haw. Exp. Sta. Bul. 60, p. 35).

Ref.—U. H. Agr. Dept. Annual Reports 1918:8; 1919:9; 1920:12; 1921:15; 1923:9; 1924:10; 1927:32; 1929:54. Planters Record (H.S.P.A.) II, 179; III, 54; V, 206.

**CRABGRASS** Crabgrass, or kukaipuaa, is a name used for three different species of *Digitaria*<sup>43</sup> which are widely distributed throughout the Territory and have moderately good value for pasturage.

Ref.—Haw. Exp. Sta. Bul. 65:17-19, 1933; Annual Report 1936:11.

<sup>43</sup>The name properly belongs to *Digitaria pruriens*.

**CROWFOOT** Crowfoot (*Eleusine indica*<sup>44</sup>), also known as goose-grass, has been in the Islands since 1902, is well distributed, and provides good pasturage.

Ref.—Haw. Exp. Sta. Bul. 65:20. 1933.

**CUCUMBER** Cucumbers (*Cucumis sativus*) of several types are grown extensively in Hawaii, practically all the local demand for the fresh product being met by our commercial and home gardeners. Pickled cucumbers are imported in considerable quantities.

To protect against the attacks of the melon fly each cucumber, when very small, must be covered by a paper bag, which adds materially to the cost of production. In spite of this and other handicaps a very good quality of cucumber is grown here, and a moderately large industry has developed with over 100 acres devoted to the crop.

A special type is grown for the Oriental trade, the "Oriental preserving melon." This cucumber is especially prized by the Chinese in the preparation of certain vegetable dishes.

See also "Melons," and "Truck Crops."

Ref.—U. of H. Agr. Ext. Bul. 16:79, 1932; Haw. Exp. Sta. Bul. 60:41, 1929.

**CUSTARD APPLE** The custard apple (*Annona reticulata*) is a tropical fruit found only rarely in Hawaii, although it deserves much more attention from our horticulturists. Both in appearance and flavor it is exotic and one must cultivate a liking for it before appreciating its full merit.

Closely related fruits which are similar in appearance but differ markedly in flavor are the cherimoya, sour sop and sweet sop.

**DAHLIA** The tuberous roots of certain species of *Dahlia*, as *variabilis*, et al., yield levulose, an uncommon and high priced form of sugar. On the mainland there is some commercial interest in the production of this sugar, but in Hawaii no serious effort has been made to develop an industry on this plant. Dahlias of several species grow

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<sup>44</sup>St. John gives *Dactyloctenium aegyptium* as the name of this grass.



readily here and perhaps could be exploited commercially but for the production of levulose the common ti plant is much more promising.

**DAIKON** See under "Radish."

**DAIRYING**<sup>1</sup> Dairy cattle were introduced to Hawaii in a limited way about the middle of the nineteenth century. Longhorn cattle had been introduced by Vancouver in 1793. Records as to when cattle were first used for dairy purposes are not complete. It is reported that William Harrison Rice started a dairy at Punahou School and pastured the cattle in the open range of upper Manoa about 1844. A commercial dairy was reported in operation on Judd Street in Honolulu in 1869 and by 1880 five dairies are reported to have been in operation in or near Honolulu.

Milk from dairy cows was a new food to the Hawaiians and they were slow in adopting it as an article of diet. It was not until an increasing number of people from foreign shores came to the Islands that a definite demand for dairy products occurred.

In the latter part of the past century, previous to Annexation, some of the beef ranches introduced dairy cows and made butter, some of which was shipped to Honolulu. At that time beef prices were very low and better returns were secured by making and selling butter. Following Annexation, prices of beef increased materially and the dairy industry in these ranches was largely abandoned, to be taken up about the same time in an enlarged way by farmers located near the cities who sold milk and the dairy industry has developed along this line. Not much butter or other manufactured dairy products are produced in Hawaii even today.

There has been a marked increase in the consumption of dairy products during the past quarter of a century. Hawaii now numbers among its people many who came from the Orient to whom milk was not a traditional food. By a program of education carried on in the schools, by

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<sup>1</sup>This statement was prepared by Prof. L. A. Henke.

various welfare agencies, and by the dairymen themselves, many of these people from the Orient as well as the Hawaiians have come to appreciate the great value of milk in maintaining their health and promoting the growth of their children. Milk is served in many of the schools of the Territory now as a health measure. Here, children acquire a taste for milk and as they grow to maturity and establish homes, they continue to use milk and give it to their children. Hence the expansion of the dairy industry has been much greater than would have been the case had it merely kept up with the increase in population.

Good, sanitary milk is being supplied by the producers and distributors of milk in Hawaii. Cattle are constantly inspected for dangerous diseases by the Veterinary Division of the Board of Agriculture and Forestry, and the Board of Health sees to it that the milk offered for sale meets all sanitary and legal requirements as regards sediment, fat, solids, and bacterial content. The fact that it is possible to buy in Hawaii high quality milk of the different grades whether certified, raw, or pasteurized, has no doubt been a big factor in increasing the demand for milk.

The data which follow concerning milk production and per capita consumption are based on the reports of milk inspectors and population estimates by the Board of Health. Milk inspectors report the number of cows and production of each herd on the days when they inspect the dairies. It is assumed that these days are average days and production for the year is computed on this assumption. There are some small, one- or two-cow family dairies from which no milk is sold and hence are not subject to inspection. Because of this, total production is slightly larger than here reported.

Imports include only such quantities of the various items as appear in the Customs reports. Comparatively small quantities of dairy and other products are brought to Hawaii from time to time by Army and Navy transports which are not included in these figures.

# MILK PRODUCTION COMPARISONS

Year	Quarts Per Day	Total Milking Cows	Calculated Production Per Year lbs.	Average Production Per Cow Per Year lbs.
Territory of Hawaii—				
1927-28 .....	39,194	.....	30,757,491	.....
1931-32 .....	51,518	7,176	40,428,750	5,634
1935-36 .....	53,459	8,020	41,951,951	5,231
Oahu—				
1927-28 .....	28,630	.....	22,467,392	.....
1931-32 .....	40,323	4,796	31,643,474	6,598
1935-36 .....	42,097	5,197	33,035,621	6,356
Hawaii—				
1927-28 .....	5,163	.....	4,051,664	.....
1931-32 .....	5,398	1,011	4,236,080	4,190
1935-36 .....	5,629	1,413	4,417,358	3,126
Maui—				
1927-28 .....	2,800	.....	2,197,300	.....
1931-32 .....	3,653	813	2,866,692	3,526
1935-36 .....	3,648	824 <sup>2</sup>	2,862,768	3,474
Kauai—				
1927-28 .....	1,801	.....	1,413,335	.....
1931-32 .....	2,044	521	1,604,029	3,079
1935-36 .....	1,964	559	1,541,249	2,757
Molokai—				
1927-28 .....	800	.....	627,800	.....
1931-32 .....	100	35	78,475	2,242
1935-36 .....	121	27 <sup>2</sup>	94,955	3,517

These production estimates show a marked increase during the eight years ending in 1936 but the big increase took place during the first four years of this period, and average production per cow is now only 5,231 pounds as compared with 5,634 pounds in 1931-32.

These figures on average production per cow per year are greatly influenced by the practice followed in some instances of using some of the better milking beef cows as dairy cows during part of the year, thereby increasing the number of so-called "dairy cows" without a corresponding increase in total production since these cows are generally inferior to the regular dairy cows.

According to U. S. Census data average production of milk per cow in 1919 was 2,508 pounds, which had increased to 5,022 pounds in 1929.

<sup>2</sup>Assuming ratio between total cows and cows in milk at one time to be the same as on Hawaii.

Per capita consumption of fresh milk has not increased since 1932; consumption figures include such fresh locally produced milk as may be used in making cream, some 400,000 gallons of ice cream, around a quarter million pounds of cottage cheese, and very small amounts of butter. The increase prior to 1932 was very marked. This is shown in the following table:

PINTS OF FRESH MILK CONSUMED PER PERSON PER DAY

	1919	1929	1932	1936
Territory .....	.11	.21	.27	.27
Oahu .....	.17	.27	.39	.39
Hawaii .....	.07	.17	.14	.14
Maui .....	.06	.16	.13	.13
Kauai .....	.05	.09	.11	.10

*Imports of Dairy Products*—There has been a constant and marked increase in imports of dairy products to Hawaii as is shown in the following comparisons:

COMPARISONS IN DAIRY IMPORTS

Year	Butter lbs.	Condensed & Powdered Milk lbs.	Cheese lbs.
1926 .....	2,177,305	5,890,760	441,918
1931 .....	3,309,671	8,752,808	530,057
1936 <sup>3</sup> .....	3,975,331	12,610,396 <sup>4</sup>	777,933

The details of imports for year ending June 30, 1936, and their approximate fresh milk equivalent follow:

DAIRY PRODUCTS SHIPPED TO HAWAII

YEAR ENDING JUNE 30, 1936

	Quantity lbs.	Value Dollars	Approximate Fresh Milk Equivalent lbs.	Per cent from Foreign Sources
Fresh milk (inc. sterilized) .....	45,632	5,603	45,632	0
Condensed milk .....	11,950,029	808,938	29,875,072	0
Dried milk, infant foods, malted milk etc. <sup>5</sup> .....	660,367	92,624	6,603,670	1.0
Butter .....	3,975,331	1,171,209	79,506,620	18.7
Cheese .....	777,933	158,534	7,779,330	0.1
<b>TOTAL</b> .....	<b>17,409,292</b>	<b>2,236,908</b>	<b>123,810,324</b>	<b>19.8</b>

<sup>3</sup>Fiscal year ending June 30, 1936.

<sup>4</sup>Includes 448,751 pounds of powdered milk.

<sup>5</sup>67% skimmed milk powder, 32% malted milk and infant foods, 1% whole milk powder.

*Proportion of Dairy Products Produced in Hawaii—*  
 With local production of fresh milk estimated at 41,951,951 pounds for the year ending June 30, 1936, and with dairy products having a fresh milk equivalent of 123,810,324 shipped to Hawaii during the same period it appears that only 25 per cent of the dairy products consumed in Hawaii were locally produced during that period.

YEARLY PER CAPITA CONSUMPTION OF DAIRY PRODUCTS  
 IN HAWAII

Year	Butter lbs.	Cheese lbs.	Condensed & Powdered Milk & Infant Foods lbs.	Fresh Milk lbs.	Approximate Whole Milk Equivalent lbs.
1919 .....	4.3	1.2	13.9	43.2	175
1928 .....	7.8	1.3	18.1	89.8	314
1931 .....	8.9	1.4	23.3	102.0	352
1936 <sup>6</sup> .....	10.1	2.0	32.0 <sup>7</sup>	106.7	422

While this shows a continued marked increase based on the whole milk equivalent, it should be noted that this increase since 1931 is largely due to an increase in the consumption of condensed milk. Seemingly we have reached a point where the per capita increase in consumption of fresh milk is very small.

Average per capita consumption on the mainland of the United States on a whole milk equivalent basis is about double the 422 pounds consumed in the Territory of Hawaii.

*Methods—*There has been a marked shift in the manner of dairying during the past fifteen years, notably on Oahu where over three-quarters of the milk of the Territory is produced. Dairies which formerly were located in or right on the edge of the city have largely been moved further out in the country, many of them across the Pali. Formerly these dairies, when nearer to Honolulu, relied for roughages largely on soiling crops produced at a high labor cost or on miscellaneous grasses, the cutting of which with a hand knife was a costly procedure often followed

<sup>6</sup>Fiscal year ending June 30, 1936.

<sup>7</sup>Includes 1.1 pounds of skimmed milk powder, an unknown part of which is used for feeding livestock and poultry.

by a long haul of about twenty miles. Now, however, they let the cattle harvest their own roughage in pastures, which is a far more economical method when land rentals are not too high.

Holstein cattle are most numerous, with Guernseys, Jerseys, and Ayrshires following in the order named. Some dairies raise calves to replenish their herd but others rely largely on the purchase of young cows secured from the mainland or outside islands, feeling that cows can be purchased more economically than they can be raised. The tendency, however, seems to be toward securing good bulls and raising more calves.

Milk production costs are high, largely due to relatively high land values and the high cost of imported concentrates. The Hawaii Experiment Station has demonstrated in repeated experiments that local, low cost by-products, as cane molasses and pineapple bran, can be used to a much greater extent than was formerly believed practicable in the feeding of dairy cows, and the use of these feeds is increasing each year.

There were 140 commercial dairies in the Territory in 1936. Many of the larger dairies operate milk routes but the bulk of the milk is sold on a wholesale basis to distributors. About 56 per cent of the total milk is pasteurized, 35 per cent is sold as raw milk, and 9 per cent is certified. Half of the total number of dairies are located on the Island of Oahu.

*Possibilities of Future Expansion*—Further expansion of the dairy industry in Hawaii will be influenced by the increase in population and by a further increase in the per capita consumption of fresh milk which is still very low compared to mainland standards.

If Hawaii is able to produce milk cheaply enough to compete with imported dairy products such as butter, cheese, and condensed milk, great expansion of the dairy industry could take place but such expansion would likely be limited to the more remote regions at elevations above those most suitable for the production of sugar and pineapples. These areas are now largely used for beef



production and hence such expansion would necessarily compete with beef ranches for the required land.

Ref.—“A Survey of Dairying in Hawaii,” by L. A. Henke, Bul. 19, Agr. Ext. Serv., U. of H., 1933. “A Survey of Livestock in Hawaii,” by L. A. Henke, Res. Publ. 5, U. of H., 1929. See also, Annual Reports of Dept. Agr. of Univ. Hawaii, 1917 to 1929; Haw. Exp. Sta. Annual Report 1936:68-70 (feeds).

**DALLIS GRASS** Dallis grass (*Paspalum dilatatum*) has been widely planted in pastures throughout the Territory in the past 20 years and is considered an excellent addition.

Ref.—Haw. Exp. Sta. Bul. 65:33, 1933.

**DANDELION** The dandelion (*Taraxacum vulgare*), which grows here very abundantly as a weed, may be used either as cooked greens or as a salad plant. Orientals and sometimes Occidentals make use of this plant as food, although its consumption thus is not great at any time. There are varieties which are sometimes found in cultivation, but not in Hawaii.

**DASHEEN** See “Taro.”

**DATE** The date is the fruit of a palm tree (*Phoenix dactylifera*) which grows to best advantage in sub-tropical desert regions. Hawaii is not an ideal country for the commercial production of this fruit, but there are some districts here in which suitable climatic conditions exist. The dry leeward portions of the Islands, in places where the soil is good and there is an ample supply of irrigation water, offer some promise for this crop, but even in such situations there is danger of a tropical rain shower falling on the bunches of fruit when they are in the final stages of maturing, and this is very injurious, as it may cause fermentation and interfere with the normal ripening processes.

The date palm was introduced into Hawaii many years ago and one may find individual trees and small clumps in many localities, but nowhere in the Islands has there been any successful commercial exploitation of this valuable fruit. Excellent bunches of dates are sometimes exhibited at county fairs here.

In 1927 the Hawaii Experiment Station secured several

hundred young plants of different varieties from Southern California, where a large date industry has been developed during the past 25 years, but no significant results have thus far appeared.

A closely related species (*Phoenix canariensis*) grows abundantly in gardens and along roadsides in Hawaii, producing bunches of small fruits which are scarcely worthy of being called edible. The pulp is thin and not very sweet, and is puckery to the taste. It has no commercial value.

Ref.—Haw. Exp. Sta. Annual Report 1927:10; Kuck and Tongg, "The Tropical Garden," p. 139.

**DERRIS** *Derris (Derris elliptica)* is a tropical plant which contains an insecticidal substance called rotenone. It is grown commercially in southern Asia and to some extent in Porto Rico. As the rotenone is concentrated chiefly in the roots, that part of the plant is harvested, dried and ground into powder.

Cuttings of this derris were obtained from the Malay Peninsula in 1934 by the P.P.C.A. Experiment Station,<sup>8</sup> in order that a test might be made of the effects of growing the plant between rows of pineapple plants; it was believed that the derris roots might give off sufficient rotenone to kill the nematodes infesting pineapple roots. Trials of this in the Wahiawa (Oahu) region have thus far proven unsuccessful and the plan has been abandoned.

The Hawaii Experiment Station is making further tests of the plant to determine whether or not there are localities in Hawaii well suited to its culture. Likewise, certain related species which also contain rotenone, are being tested. Some of these were obtained by the Station in 1930 and have been under trial since.

**DUCKS** Raising of ducks both for meat and eggs is practiced in Hawaii to a limited extent, mostly by Chinese farmers and suburban householders. Hawaii offers favorable conditions for this industry, and it ought to be expanded.

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<sup>8</sup>About the same time the Agricultural Extension Service obtained cuttings of derris from the Philippine Islands and distributed them for trial planting to several collaborators in various parts of the Territory.

See also "Poultry."

Ref.—Haw. For. Agr. 1911:253 (on feeding ducks).

**DURIAN** The durian (*Durio zibethinus*) is a Malayan tree which produces a large fruit somewhat resembling a breadfruit except that its exterior is covered with coarse, thorny warts. The pulp is of excellent flavor but has a very offensive odor. There are very few trees in Hawaii.

**EGGPLANT** The eggplant (*Solanum melongena*) is well adapted to the sub-tropics and thrives particularly well in Hawaii. Two varieties are commonly grown here, a round type and an elongate type. One or both are found in most truck and home gardens, for culture is easy and the market demand constant. A recent crop survey (1936) shows between 50 and 75 acres in the aggregate devoted to this crop.

Ref.—U. H. Agr. Ext. Bul. 16:91, 1932; Haw. Exp. Sta. Bul. 60:38, 1929.

**EKO** See "Koahaole."

**ELEPHANT GRASS** Elephant grass, or Napier grass (*Pennisetum purpureum*) was introduced into Hawaii in 1915 by the Hawaii Experiment Station and in the ensuing twenty years has become of great importance in pasturage. It is also used extensively as fodder, and as a soiling crop. When used as fodder it is cut every 30 days to prevent its becoming too large and coarse. Yields of 100 tons of green fodder per acre per year are not uncommon.

As suggested by its name, this grass grows to gigantic size in comparison with most species, rivaling sugar cane in this respect. When a field of elephant grass is to be used for pasturage cattle must be kept out until the grass is about three fourths grown, after which it will stand the normal trampling well. It is palatable and nutritious, and cattle come off it in prime condition. It is considered an excellent fattening grass in wet districts.

Merker grass is a closely related species which is not considered as valuable as elephant (Napier) grass.

Ref.—Haw. Exp. Sta. Bul. 65:40, 1933; also Bul. 72, "Napier Grass, A Pasture and Green Fodder Crop for Hawaii;" Annual Report 1936:11, 21; also U. H. Agr. Dept. Annual Reports 1922:49; 1924:34; 1925:43; 1926:33; 1928:35.

**ENDIVE** This lettuce-like salad plant (*Cichorium Endivia*) is found but rarely in vegetable gardens of Hawaii. Importations from the mainland amount to about 20,000 pounds per year. Consumption is mostly in the tourist hotels.

See also "Truck Crops."

**EUCALYPTUS** Several species of *Eucalyptus* were introduced into Hawaii from Australia during the early years of the current century and seemed to find very congenial conditions here. Since certain species are used in Australia as important sources of lumber and ship timbers, it was urged that Hawaii should make an effort to establish forests of *Eucalyptus* for future commercial use when present forest resources might be depleted.<sup>1</sup> Thousands of seedlings were planted, especially on Maui and Oahu by the Board of Agriculture and Forestry to determine their economic value under Hawaiian conditions.

As a source of lumber not any of the *Eucalyptus* species have yet proven to be worth commercial exploitation in Hawaii, because of the strong tendency of the wood to check and split.

For fence posts the *Eucalyptus* is not as good as the Ohia, Koa, Mamani and some other native woods, but is used extensively on some ranches where it is abundant and more readily available than the other kinds. When properly creosoted these posts last a good number of years.

As fuel wood, *Eucalyptus* is especially valuable, for it grows rapidly and lends itself well to being used in this way. Tests show that certain species are superior to others in this regard.<sup>2</sup>

The tannin extract from *Eucalyptus* leaves is useful in removing scale from boilers.<sup>3</sup>

Certain oils and other valuable commercial articles are derived from the *Eucalyptus* in Australia, but thus far no serious efforts have been made to develop such an industry here.

Many hundreds of acres of land at elevations of 1,000

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<sup>1</sup>Haw. For. Agr. 1911:229-231. Also, see Planters Record IV, p. 82 (1911).

<sup>2</sup>See two articles by C. S. Judd in Hawaiian Forester and Agriculturist 1915:24, and 1919:20-24.

<sup>3</sup>Planters Record Vol. III, p. 289 (1910).

to 5,000 feet are covered by Eucalyptus in these Islands; in some cases (as Waialua) these plantings are a source of some revenue, while in others they are considered more as a liability than an asset.

**EUGENIA** This is a genus of tropical trees, with many species scattered throughout the tropics. A few have been introduced into Hawaii during the past hundred years, and two of them, the mountain apple and Java plum, have established themselves in the wild state. None of them have been thought to offer sufficiently attractive economic possibilities to justify cultivation on a commercial scale in these Islands, but perhaps the Surinam cherry should be given such a trial. The species occurring in Hawaii are:

Brazilian Plum  
Java Plum  
Mountain Apple  
Rose Apple  
Surinam Cherry  
Water Apple

**EUPHORBIA LORIFOLIA** In 1912 J. F. Rock discovered a large stand of a native Hawaiian species of *Euphorbia* on the Island of Hawaii. Since all species of this genus have milky sap in abundance and some are valuable sources of rubber, he took samples of the latex to be analyzed, for at that time Hawaii was much interested in the possibility of developing a large rubber industry.

Analyses were not encouraging, however, for in comparison with Ceara this *Euphorbia* latex was very low in rubber content, and in quality, also, it was inferior.

As a source of chicle, for chewing gum, the newly discovered Hawaiian tree seemed to offer some promise, but no serious efforts were made to develop its manufacture here.

For further information on the subject of rubber, see "Rubber."

Ref.—Haw. Exp. Sta. Press Bul. 37 (1912). Thrum's Annual 1913:149 (E. V. Wilcox).

**FAYA** The faya is a large shrub or small tree (*Myrica faya*) with fragrant wood which is used in Portugal for incense purposes. The leaves, also, are somewhat fragrant. It was introduced into Hawaii some few years ago from the Madeira Islands, and now is spreading rapidly in some of the upland areas of the Island of Hawaii, causing alarm among the ranchers operating there. The seeds are disseminated by birds. Thus far no commercial value has been attached to this tree in Hawaii.

**FEEDS FOR LIVESTOCK** Hawaii produces many kinds of crops and products which are used to a greater or lesser extent in feeding livestock; in addition there are some which have been tried but not developed as regular crops. Each of the following is discussed briefly in its alphabetical order:

Alfalfa	Molasses
Algaroba	Pigeon pea
Bagasse	Pineapple bran
Buckwheat	Salt bush
Carob	Sorghum
Cassava	Sugar
Corn	Sunflower
Cowpea	Sweet clover
Grasses of many kinds	Sweet potato
Honohono	Uba cane
Hubam clover	Velvet beans
Koahaole	Vetch

Raw sugar has been used experimentally as a feed for livestock. When 5 to 10 per cent of the ration for hogs is raw sugar, the appetite of the animals is stimulated<sup>1</sup> and more feed is consumed, resulting in an increase of daily gains in weight. If the cost of raw sugar is low, this may reduce the unit cost of fattening swine. At ordinary prices, however, raw sugar is not an economical feed for livestock.

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<sup>1</sup>U. H. Report of Agr. Dept. for 1929, p. 35.



**FEIJOA** The feijoa (*Feijoa sellowiana*), called also pineapple guava, is a close relative of the guava and resembles it in shape and structure of both fruit and flower. It is a shrub with more value as an ornamental than as a commercial source of fruit, for in Hawaii it does not thrive as well as the guava, nor is its fruit in demand in our markets. It was introduced about 20 years ago from California, where it is developing as a commercial fruit of some importance. It occurs in some gardens here, but not commonly.

See also "Guava."

Ref.—Haw. For. Agr. 1917:366-368.

**FERN** See "Tree Fern."

**FERN TIPS** The tender tips of certain ferns as *Pteridium aquilinum*, are commonly used as food in Hawaii, especially by Orientals. Neither of these ferns is cultivated, for they are abundant in certain forest areas and may be had for the gathering.

The tips of the young fronds, when still tender and succulent, may be eaten if first stripped of their velvety covering, soaked overnight in water to remove an unpleasant acid, and cooked according to standard recipes.<sup>2</sup>

See also "Tree Fern."

**FESCUE GRASS** Fescue grass, or brome fescue (*Festuca dertonensis*), is widely distributed and usually grazed closely by cattle, showing that it is relished.

Another species, *Festuca elatior*, is under trial and may prove to be more valuable.

Ref.—Haw. Exp. Sta. Bul. 65:21-22, 1933.

**FIBER CROPS** The production of fibers for industrial purposes is highly developed in some countries but in Hawaii is of very minor importance in proportion to other industries. This latter fact is not due, however, to any lack of effort to establish such industries, for a goodly

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<sup>2</sup>Haw. Exp. Sta. Bul. 60, p. 29, 1929.

number of fiber crops have been tried or proposed here:

Broom fibers—

broom corn

Cloth fibers—

banana

cotton

flax

pineapple

silk

Matting, mats, basketry, etc.—

coconut

lauhala

matting sedges

Paper fibers—

bagasse

bamboo

malina

Rope fibers

bowstring hemp

manila hemp

olona

ramie

sisal

sun hemp

Stuffing and upholstery fibers—

cotton

pulu

Thatching and building fibers—

coconut

lauhala

pili

sugar cane (bagasse)

**FICUS** See "Fig," also "Rubber."

**FIG** There are a very large number of species of trees which produce figs, belonging to the genus *Ficus*; some of them, as the banyans, grow to immense size and are important features of tropical vegetation. Only a few of the species produce fruit that is marketable, and these are cultivated chiefly in sub-tropical regions. At least

one kind of edible fig, though it is not known which, was introduced by Marin sometime prior to 1813. As all fig species are easily propagated from cuttings and since fig cuttings will withstand long exposure before being planted, it followed naturally that many introductions of this fruit tree were made. It was frequently mentioned in meetings of the Royal Hawaiian Agricultural Society<sup>3</sup> as being well adapted to Hawaiian conditions and a very useful item in the list of fruits cultivated here.

Four varieties were noted in 1851: bush fig, tree fig, China fig and Turkey (Smyrna) fig, the last being considered the best for all practical purposes.

Some limited efforts were made to establish a dried-fig industry in the 1850's and at various times subsequently, but the climate proved not to be quite suitable and nothing of large commercial importance ever developed in this line.

Some have urged, and still declare, that there are great potential possibilities of fig production in these Islands, but no serious effort has been put forth to realize them. Fig growing today is limited chiefly to home gardens, with here and there a small commercial planting, the total of which is under 50 acres. The fruit fly is a hindrance to successful production. The species cultivated is *Ficus carica*, a large, dark-colored variety. The Kadota and Black Mission varieties are under test at the Kona branch of the Hawaii Experiment Station (Annual Report 1936, p. 95).

Ref.—Haw. Exp. Sta. Bul. 77:27-29 (uses of fig); Planters Monthly X, 227; XIX, 519.

**FLAX** Flax (*Linum usitatissimum*) seems to prosper better in temperate and subtemperate regions than in the tropics. A few trials of this fiber plant were made by the Hawaii Experiment Station some twenty years ago, but the results were not sufficiently encouraging to warrant commercial planting. The yield of seed was good, at the rate of 17 bushels per acre in two plantings, but the yield of straw for fiber was disappointing.

Many years earlier (1851) an effort was made to estab-

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<sup>3</sup>For example, Trans. Royal Haw'n Agr. Soc. Vol. I, No. 2, p. 81 (1851) and No. 3, p. 118 (1852).

lish a flax industry here<sup>4</sup> but with no success. This effort was directed toward the production of fiber; it is possible that flax grown for the oil content of its seed (linseed oil of commerce) would prove to be a profitable basis for an industry in Hawaii.

This plant "requires<sup>5</sup> a light soil well prepared before planting, germinates in 4 days under good conditions, and matures usually in 90 days. It can be drilled or broadcasted, care being taken to insure an even stand when fiber is wanted for manufacture."

J. F. Rock collected specimens of this plant in the wild state in 1914 on Haleakala Ranch, Maui.

**FLORICULTURE** An important feature of agriculture in Hawaii is the commercial production of flowers for use in bouquets and especially in leis. The most widely cultivated kinds are carnations, chrysanthemums, ginger, plumeria and pikaki. While no exact figures are available, it is known that a very extensive industry has been developed in the commercial production and sale of these flowers, amounting in the aggregate to well over \$100,000 in a typical year.

For information concerning these and floriculture in general the reader is referred to "The Tropical Garden" by Kuck and Tongg (Macmillan, 1936). Also, an article by R. I. Lillie in *Hawaiian Forester and Agriculturist* 1920:6-9.

**FLOWERS** See "Floriculture."

**FORESTS AND FOREST PRODUCTS** Forests cover about 27 per cent of the total area of the Hawaiian Islands. Most of this is set aside by proclamation of the Governor as forest reserves, in order that this important part of Hawaii's natural resources may be conserved to the best possible advantage. The forest reserves are administered by the Territorial Board of Agriculture and Forestry, which maintains rangers to supervise and protect them from injury and damage.

<sup>4</sup>Trans. Royal Haw'n Agr. Soc. Vol. I, No. 2, p. 105.

<sup>5</sup>Quoted from Haw. Exp. Sta. Annual Report (1914) p. 40.

The following table<sup>6</sup> indicates the distribution of the forest reserves and the ratio to the entire land area on each island:

Islands	Total Area (Acres)	Areas in Reserves (Acres)	Areas in Forests (Acres)
Kauai .....	350,000	146,197	170,000
Oahu .....	382,720	117,210	140,000
Molokai .....	167,000	44,674	70,000
Maui .....	466,000	131,504	✓ 150,000
Hawaii .....	2,570,000	477,392	564,000
Lanai .....	89,305	.....	4,000
Kahoolawe .....	28,260	.....	2,000
TOTAL .....	4,053,285	916,977	1,100,000

The Hawaiian forests are tropical and therefore lack the pines, spruces and other coniferous trees familiar to the temperate zone forester. Instead of these, there are several Hawaiian trees usually of an evergreen nature, although some shed their leaves for a short period at certain seasons. The more common species are the following:

(1) The Kukui or Candlenut tree, which produces an oily nut used by the early Hawaiians for illuminating purposes, and whose frosted light-green foliage makes the tree very conspicuous, especially in the gulch bottoms and on slopes at the lower portions of the wet valleys.

(2) The Koa or Hawaiian Mahogany, which belongs to the Acacia family and which is found on well-drained soil on the slopes and ridge-tops. This furnished the natives with the large bodies for their dugout outrigger canoes, and the beautifully grained brown wood now is made into musical instruments, furniture and interior finish.

(3) The most abundant tree throughout the Hawaiian wet forests is the Ohia Lehua, a genus which has affinities in New Zealand. The blossoms of this tree are a bright scarlet pompon, sometimes yellow, and of them the old Hawaiian always spoke with that sort of tenderness with

<sup>6</sup>This table and the paragraphs which follow it are taken from the first of a brief series of "Agricultural Studies" published by the University of Hawaii; Mr. C. S. Judd, Territorial Forester, collaborated in the preparation of the publication mentioned.

which a Scotchman speaks of heather. The Ohia is slow-growing and very hard to raise from seed, but it thrives on thin soil in exposed places, and comes in quickly on the new lava flows where moisture is present, making thus a very valuable component of the native flora. The wood is extremely hard and is excellent for flooring.

(4) Other trees found in association are the Kopiko, Kolea, Ahakea, Kauila, Kalia, Lama, Mamake, Naio and Olopua, with often an undergrowth of tree ferns, ie-ie and maile vines, and other abundant shrubbery.

(5) At the higher elevations on Maui and Hawaii the Mamani is found near the timber line up to 8,000 feet above sea level. This is a tree belonging to the bean family with bright yellow sweet-pea-like blossoms. The Mamani has the most durable wood of all the Hawaiian trees, and is highly prized by the ranchers for fence posts.

(6) Along the shore and growing not far inland may also be found the Milo, Kamani of two species, the coconut, and the rambling Hau. The latter furnishes a tough bark used for cordage.

(7) The Kou tree, most valuable because its wood was easy to work and made excellent calabashes and food dishes, is now becoming rare because of a defoliating moth.

The value of forest products varies from year to year according to amounts harvested. In 1903 the estimated value was about \$125,000,<sup>7</sup> including lumber, fence posts, tanbark, etc. Koa lumber to the value of \$10,094 was taken out in 1905 and about \$13,000 worth in 1907. In the preceding century the sandalwood trade yielded very large returns while it lasted, but now is no more (see "Sandalwood").

During the past twenty years there has been a fundamental change in the attitude of this Territory toward its forests; instead of exploiting them and taking out as much as possible in the way of timber and other commercial materials, the present policy is to protect and build up the forest cover as much as possible, for its

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<sup>7</sup>Thrum's Annual 1903:61.

beneficial influence on rainfall and soil conservation. Consequently, there is very little activity in the way of lumbering or other exploitation of the forests.

Ref.—Haw. For. Agr. 1927:40-47 (an excellent statement of forest resources in Hawaii, past and present, by C. S. Judd). U. H. Agricultural Studies, No. 1, "Hawaiian Forest Areas," 1927. Thrum's Annual 1884:30-32 (J. M. Lydgate); 1891:87-91; 1892:88-89; 1903:61; 1906:45; 1932:61-69 (C. S. Judd on rare and near extinct species).

**FRENCH CHERRY** See "Surinam Cherry."

**FROGS** Frog raising has been indulged in by a few people in Hawaii now and then during the past several decades, but always on a very small scale. While there is a moderately good demand for this product in hotels, restaurants and ships, there are many hazards to be overcome in the raising of frogs and one should not go into the business without a thorough study of its requirements and risks.

At present there is some frog production on Kauai and a small amount on Oahu. The market could absorb more.

For detailed information on frog culture, see University of Hawaii Agricultural Extension Service, Agric. Notes No. 117 (Oct. 11, 1935).

**FRUITS** Horticulture in Hawaii has given a more or less thorough trial to the growing of many kinds of fruits and nuts, some of them of temperate zone origin but most of them tropical; a few kinds have become of large economic importance to this Territory, some others seem to offer promise of becoming so, but many will probably continue as horticultural rarities of interest chiefly to the fancier of new fruits.<sup>8</sup>

In their alphabetical order the following fruits are discussed in relationship to their potentialities for Hawaii:

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<sup>8</sup>The best treatise on the nutritive values and uses of Tropical Fruits in Hawaii is Bulletin 77 of the Hawaii Experiment Station (1936), by C. D. Miller, K. Bazole and R. Robbins.



Akala berry  
 Apple  
 Apricot  
 Avocado  
 Banana  
 Bhel  
 Brazilian plum  
 Breadfruit  
 Cactus pear  
 Carambola  
 Carissa  
 Cherimoya  
 Cherry  
 Chinese orange  
 Citron  
 Custard apple  
 Date  
 Durian  
 Feijoa  
 Fig  
 Grapefruit  
 Grape  
 Guava  
 Java plum  
 Jackfruit  
 Jujube  
 Kumquat  
 Lemon  
 Lilikoi  
 Lime  
 Litchi  
 Longan  
 Loquat  
 Mammee

Mandarin orange  
 Mandrake  
 Mango  
 Mangosteen  
 Monstera  
 Mountain apple  
 Mulberry  
 Ohelo  
 Olive  
 Orange  
 Papaya  
 Passion fruit  
 Peach  
 Persimmon  
 Pineapple  
 Poha  
 Pomegranate  
 Quince  
 Raspberry  
 Rose apple  
 Roselle  
 Sapota  
 Sour sop  
 Star apple  
 Strawberry  
 Surinam cherry  
 Sweet sop  
 Waiawi  
 Wampi  
 Water apple  
 Waterlemon  
 Watermelon  
 Wi

**FUNGUS** See "Pepeiao Akua," also "Mushroom."

**GARLIC** Garlic (*Allium sativum*), especially delectable to certain racial groups, is produced in Hawaii only in very limited quantities, some 25 acres being devoted to it in 1936. Larger amounts are imported than are produced here.

Its culture is similar to that of the onion.

See "Onion," also "Truck Crops."

**GEESE** The raising of geese is practiced in Hawaii only to a limited extent, chiefly for home consumption.

See "Poultry."

**GINGER** Commercial ginger comes from the roots of a tropical plant (*Zingiber officinale*) which grows well in Hawaii. There are many other species of ginger, some of them producing exceptionally beautiful flowers which are much prized in Hawaiian gardens. Several species grow wild in the mountain valleys, beside streams where the jungle shade and an abundance of water combine to provide ideal conditions.

Although our wild gingers have spicy root-stalks, for commercial use they are not considered the equal of the species named above which has become known to the trade as Jamaica ginger. This and certain similar varieties have been introduced here and are being grown successfully, but in comparatively limited amounts. A recent survey indicated that the total commercial plantings of ginger (for roots) in the Territory amount to only six or seven acres. The Prohibition era gave an unusual stimulus to the manufacture of ginger ale and, of course, there was a rise in the prices of ginger root which caused a little flurry of interest in Hawaii in 1924 to 1928. It was found, however, that because of higher wage standards and higher land values these Islands could scarcely compete with the West Indies and Central America.

Prevailing prices now vary from six to ten cents per pound, and with average production less than 2,000 pounds per acre, the net income is not very great.

Most of the ginger root produced here is consumed locally, only about ten per cent being shipped to the mainland. Consumption is not all in the making of ginger ale, for an appreciable quantity is used by the Chinese in flavoring certain foods.

The flower bracts of one species of ginger (*Zingiber mioga*) are used as a flavoring for soup by both Japanese and Chinese. This species is but sparingly cultivated in Hawaii.

The flowers of some of the species of ginger (especially

*Hedychium coronarium*) are used extensively in the making of leis, which are sold in very large numbers. While there is no exact information as to the extent of this business, it is estimated that between \$100,000 and \$200,000 annually is realized from this exotically lovely and fragrant flower.

Ref.—Haw. Exp. Sta. Annual Report 1926:12; 1927:14; 1928:13; also Bul. 60:12.

**GOA BEAN** This little known bean (*Psophocarpus tetragonolobus*) is a recent introduction from India and gives some promise of becoming very popular. Its pods are "winged" along the angular edges, and when immature are succulent and have a delightful flavor. Cultivation in Hawaii is very limited.

Ref.—Haw. Exp. Sta. Bul. 60:40, 1929.

**GOATS** The first goats in Hawaii were brought here in 1778 by Captain Cook. From this and a few subsequent introductions they became exceedingly numerous, living wild in the mountains. Their economic value to the Islands has never been great, however, for as a source of meat they are not held in as high esteem as certain other animals.

The only source of revenue from wild goats of any considerable importance is the hide. Goat skins have been exported in varying amounts, but the total value of these shipments in any one year has never been great; in 1850 the exports were 26,519 skins, valued at \$3,977; in no subsequent year did the annual shipments equal those of 1850 in numbers of skins, but in some years the unit prices went much higher and brought the total value to higher figures, \$15,573, for example, in 1885.

In the present century there has been very little business in the collecting and using or exporting of goat skins, annual shipments having dwindled by 1900 to a value of \$1,721.

Far more than offsetting this small economic value is the damage done by wild goats to forests and pastures, which make them more of a liability than an asset. Efforts have been put forth by ranchers and by the Board of Agriculture and Forestry for many years to exterminate this pest and on most of the islands they have been success-

ful. On the Island of Hawaii, however, large numbers still remain. In 1922 an extensive "drive," using a hundred or more men and boys on horseback, resulted in the rounding up and killing of 7,000 goats from the Puu-waawaa section. At that time it was estimated that there were about 68,000 on the Island.

The keeping of domestic goats, chiefly for their milk yield, has never been developed in Hawaii to any considerable extent, although a number of efforts have been made to establish such an industry. In the 1920's a considerable wave of interest in the Toggenberg breed for milk purposes was aroused by W. Twigg-Smith.

Ref.—Thrum's Annual 1906, pp. 48-55. Haw. For. Agr. 1922:244-248 (C. S. Judd); Planters Monthly VI, 384.

**GOBO** See "Burdock."

**GOOSEBERRY** See "Poha."

**GOOSE GRASS** See "Crowfoot."

**GOURD** Gourds of many species abound in the subtropics and tropics, most of them, however, not being fit for use as food. Among the economic plants noted by Captain Cook as having been in Hawaii prior to his arrival was a species of calabash gourd used for holding water and foods. This and similar species are still grown on a small scale.

The dishcloth gourd (*Luffa acutangula*) is an introduction from southern Asia and is used chiefly by the Chinese. The mature fruits are a foot or two in length and only an inch or two in diameter, but are always harvested when immature and comparatively small, for only then is the flesh succulent and good to eat. The exterior of the fruit is characteristically ribbed, which makes it resemble somewhat the okra; in fact, it is sometimes called "Chinese okra," but is very distinct botanically.

This gourd is found in many vegetable gardens, grown for market, the total acreage devoted to it being probably less than 20 acres.

Ref.—Haw. Exp. Sta. Bul. 60:37, 1929.

**GRANADILLA** See "Passion Fruit."

**GRAPE** A small industry in the growing of grapes

has existed in Hawaii for a hundred years or longer, but it has never developed to any considerable size. In 1815 a Spaniard, Francisco Marin, who had been in Hawaii for a number of years, wrote in his journal that on a certain day he "was planting vines for the King." In all probability that was the Isabella wine grape (*Vitis Labrusca*) from Madeira, for it is known that this variety came to Hawaii at a very early date. Its cultivation was taken up by a few people, but apparently did not become general. This was perhaps due to two factors: (1) climatic and soil conditions did not prove to be ideal; and (2) there was a considerable popular opposition to wine manufacture because of strong missionary influences. By 1850 grape growing had made so little progress that a contemporary<sup>1</sup> writing of "the Vine and Tobacco" states that what little grape culture there was at that time was very poor.

Imported wines were so costly, however, that in spite of handicaps of climate and public opinion efforts were repeatedly made to develop an industry for at least sufficient production to take care of local consumption needs. In 1852 John Montgomery<sup>2</sup> brought in some fifty varieties of grapes from Australia in the hope that some might prove to be better than the kinds already here. He was enthusiastic about the possibilities of this industry, as indicated by his exclaiming on "how many hundreds, nay thousands of acres of waste land might be converted into smiling vineyards, yielding their tens of thousands yearly to the meagre produce of our Islands."<sup>3</sup> He reckoned an acre of vines worth \$1,000. No great success resulted, however, from these efforts and grape growing continued at about the same low level with occasional spurts of renewed interest. The Isabella still was considered the best variety for Hawaii, and no good table grape had been found which would produce well here.

When in 1901 the U. S. Department of Agriculture was surveying the general situation in this newly annexed Territory with a view to establishing an agricultural experiment station as a means of fostering diversification

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<sup>1</sup>George M. Robertson, Trans. Royal Haw'n Agr. Soc. Vol. I, No. 1, p. 71.

<sup>2</sup>George M. Robertson, Trans. Royal Haw'n. Agr. Soc. Vol. I, No. 4, p. 8.

<sup>3</sup>Trans. Royal Haw'n Agr. Soc. Vol. I, No. 4, p. 31 (1853).

of farming, the small industry in grape growing then existing was noted among many other crops as a possibility for expansion. The Portuguese population was increasing steadily by new immigration at that time and the new Experiment Station undertook to introduce new grape varieties in response to the interest of this important racial group. In 1905-6 some 175 new varieties were brought in for trial at Makawao, Maui, where a commercial vineyard was being projected in large dimensions. At about that time, too, there were ambitious beginnings in the vicinity of Hilo. In 1911 the interest in grape growing was sufficiently general and popular to cause the Legislature to request the Experiment Station to issue a special bulletin on the subject in the Portuguese language. Meanwhile, a good deal of attention was being given by the Station specialists to problems of fertilizing and pruning of the vine, to the development of the most efficient type of trellis, and to the control of insect pests. The "Japanese beetle" (*Adoretus*) was proving to be exceedingly destructive, by devouring the foliage. Poison sprays were recommended, but were not very effective in regions where frequent rains washed the poison off the leaves.

The net result of trying many different varieties during all these years was the establishment of the Isabella as the best for Hawaiian conditions, thus confirming the findings of the early vineyardists. It alone seems to be able to withstand the nematode worms in the soil which attack the roots of most all others so effectively that they die in a year or two. Notwithstanding the interest and assistance of the Experiment Station and of the Legislature, and in spite of the ambitious beginnings made at Makawao and Hilo, the grape and wine industry has never developed beyond the stage of infancy. At no time has there been a total area of as much as 100 acres in producing vineyards, and the total today is considerably less than fifty acres, nearly all of it near Hilo. On each of the other islands there are small home plantings aggregating only a few acres in all.

Ref.—Haw. Exp. Sta. Annual Report 1902:321; 1906:12; 1911:35; 1917:13; 1920:21; 1921:17; 1922:6; 1923:5; 1924:5; 1925:6; 1927:5; 1936:95; also, Bul. 77:30-32 (uses of Isabella grape).

**GRAPEFRUIT** The grapefruit (*Citrus grandis*), widely familiar as a breakfast fruit, is better adapted to the tropics than are the common orange and lemon, which are close relatives. Although introduced into Hawaii a good many years ago, it has not been planted extensively for commercial purposes, perhaps because of the fact that the Mediterranean fruitfly attacks it more destructively than most other fruits.

The largest commercial planting is in the Puna district of Hawaii where one orchardist<sup>4</sup> has several acres under cultivation, with a ready market in Hilo for all that he produces. Many home gardens contain a tree or two, for household use. The Hawaii Experiment Station has propagated and distributed several good varieties.

Pomelo is a name sometimes used synonymously with grapefruit, but more commonly it refers to a large, thick-skinned, coarse type grown in China and prized for the fragrance of its rind.

Shaddock is another name commonly used for the Asiatic pomelo.

**GRASSES** Some 49 species of grasses of more or less value as feed for range cattle are present in Hawaii, some widely disseminated while others are still in the process of becoming established. Some of these grasses are very valuable in that they have made it possible to raise more cattle per unit area, thereby enhancing the worth of the livestock industry to the Territory.

The Hawaii Experiment Station has made many introductions and tried many species in its several grass gardens maintained at various elevations. In addition to these introductions several other kinds have been brought in by ranchmen. Some have come in accidentally as seeds lodged in imported hay and may be pests rather than beneficial. All that have been successful, or seem promising, are included in the list below, together with a few common species that are relatively valueless. In their proper alphabetical sequence some of the species are very briefly treated; for a detailed statement about all of them see Bulletin 65 of the Hawaii Experiment Station, "Range

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<sup>4</sup>Mr. K. Iwasaki, a graduate of the University of Hawaii.



Grasses of Hawaii," published in 1933. A later bulletin, No. 76, discusses the factors affecting the chemical composition of pasture grasses, for this is basic to the nutritive value of these grasses as cattle feed.

The grasses of interest to livestock producers in Hawaii are these:

*Agrostis alba*—Redtop grass  
*Andropogon annulatus*—Angleton grass  
*Andropogon nodosus*—Wilder grass  
*Andropogon saccharoides*—Silver beardgrass  
*Andropogon sericeus*—Australian bluegrass  
*Anthoxanthum odoratum*—Sweet vernal grass  
*Arrhenatherum elatius*—Tall oatgrass  
*Axonopus compressus*—Carpet grass  
*Bromus unioloides*—Brome grass  
*Chloris gayana*—Rhodes grass  
*Cynodon dactylon*—Bermuda grass  
*Dactylis glomerata*—Orchard grass  
*Digitaria pruriens*—Crabgrass  
*Digitaria sanguinalis*—Crabgrass  
*Digitaria violasceus*—Crabgrass  
*Eleusine indica*—Crowfoot  
*Festuca dertonensis*—Brome fescue  
*Festuca elatior*—Tall fescue  
*Heteropogon contortus*—Pili grass  
*Holcus lanatus*—Velvet grass  
*Ixophorus unisetus*—Mexican grass  
*Lolium multiflorum*—Italian ryegrass  
*Melinis minutiflora*—Molasses grass  
*Microlaena stipoides*—Meadow rice grass  
*Oryzopsis miliacea*  
*Panicum maximum*—Guinea grass  
*Panicum purpurascens*—Panicum  
*Paspalum conjugatum*—Hilo grass  
*Paspalum dilatatum*—Paspalum grass.  
*Paspalum fimbriatum*—Panama paspalum  
*Paspalum notatum*—Bahia grass  
*Paspalum orbiculare*—Rice grass  
*Paspalum urvillei*—Vasey grass  
*Pennisetum clandestinum*—Kikuyu  
*Pennisetum complanatum*

*Pennisetum purpureum*—Elephant or Napier grass

*Phalaris tuberosa*

*Poa pratensis*—Bluegrass

*Rhaphis aciculata*—Pilipiliula

*Sacciolepis contracta*—Glenwood grass

*Setaria lutescens*—Yellow foxtail

*Setaria verticillata*—Bristly foxtail

*Sorghum vulgare sudanensis*—Sudan grass

*Sporobolus berteroanus*—Rattail grass

*Stenotaphrum secundatum*—Buffalo grass

*Trichachne insularis*—Silk grass

*Tricholaena rosea*—Natal grass

Ref.—Haw. Exp. Sta. Bul. 65 and 76. Also, U. H. Agr. Dept. Annual Reports 1925:40; 1926:34; 1927:34; 1928:36; 1929:55.

**GUAVA** There are two principal species of guava in Hawaii: the red strawberry guava (*Psidium cattleianum*) and the common species (*Psidium guajava*), the latter occurring in several varieties, including the so-called "white" variety, the "sweet" variety, and others.

The strawberry guava is of common occurrence in home gardens but seems not to have been able to establish itself in the wild state except possibly in a few limited areas. Although it has some commercial possibilities it has never been cultivated on that basis, probably because of the abundance of the common (yellow) species.

The common species has become the dominant ground cover in many uncultivated foothill areas and on some mountain slopes, crowding out many other types of vegetation and in some instances ruining pastures.<sup>5</sup> Many thousands of acres have thus been occupied by this hardy shrub, the origin of which in Hawaii is not known with certainty. It probably was introduced early in the nineteenth century as a garden shrub and escaped into the wild, disseminated by birds.

Perhaps the most serious indictment against the guava is not, however, its occupation of good land and the expensiveness of clearing it away for the cultivation of other crops, but the fact that it harbors the Mediterranean fruitfly and makes it practically impossible ever to exterminate this pest. While there are principal fruiting seasons, there are some fruits to be found at any time of

<sup>5</sup>Haw. For. Agr. 1904:191.

the year, thus assuring a perpetual source of food for this fruitfly which is the direct cause of costly restrictions against the shipping of many kinds of fruits to the American mainland.

Such are the liabilities of the guava, but there are items to enter on the other side of the ledger. It produces thousands of tons of fruit every year, much of which is gathered and used for jelly-making both commercially and in countless homes. Any estimate of the value of this would be a guess, but it is probable that the total is over \$100,000 per year.

Recent studies in the Nutrition Laboratory of the local University show that guava juice has nearly four times the vitamin value of orange juice as a preventive of rickets and similar disorders.

As an ingredient of fruit punches guava juice is proving to be very desirable and it is not impossible that a major industry might develop out of the beginnings made in the use of this fruit which grows so abundantly here.

Almost no effort has been made to cultivate the common guava in Hawaii, although in some other countries it is under regular cultivation. It is quite possible that the application of science to the selection of superior strains and to the proper cultivation of the shrub might greatly increase the quantity per unit area and the quality of the product so that the guava could become a feature of great economic importance in these Islands, instead of a liability.

The *waiawi*, or mandrake, is a variety of the strawberry guava but is more a tree than a shrub. Its fruit is orange yellow and somewhat inferior in flavor, but is eaten to some extent. The tree is a handsome ornamental and occurs not uncommonly in gardens.

See also "Feijoa."

Ref.—Trans. Royal Haw. Agr. Soc. 1851, p. 82. Haw. Exp. Sta. Bul. 47 (1923) on jelly-making; Bul. 77:34-42 (uses and recipes); Annual Report 1902:320; Kuck and Tongg, "The Tropical Garden," p. 158. Wilder, "Fruits of the Hawaiian Islands," (1911), p. 118-131.

**GUAYULE** Guayule (*Parthenium argentatum*) is a desert shrub, occurring in northern Mexico and southwestern United States, the latex of which is used com-

mercially in the making of rubber. During the past quarter century there has been some interest in the southwestern states in the cultivation of this plant on an extensive scale, as a means of providing a domestic source of rubber.

Some 25 years ago the Cookes undertook to establish this plant on Molokai, where it was believed the conditions for it were ideal. An investment of several thousands of dollars was made in obtaining a supply of guayule seed in Mexico and in preparing the land for planting. Unfortunately, however, the seed failed to germinate, and the project was abandoned.<sup>6</sup>

**GUINEA GRASS** Guinea grass (*Panicum maximum*) is becoming widely distributed and in some localities is highly valued for pasturage. It was first introduced by D. M. Forbes in the 1880's.

Ref.—Haw. Exp. Sta. Bul. 65:30, 1933.

**HALA** The leaves of the hala tree, or screw pine (*Pandanus odoratissimus*), provide excellent material for the weaving of mats, hats and many other useful articles, and have been used in this way by the Hawaiians for many centuries. Before the coming of western civilization it was by far the most important fiber plant in these Islands.

The economic value of this tree in those early times is difficult to estimate, but certainly it was relatively great. During that period, however, and even down to the present century the products of this fiber plant were chiefly for local use; in the nineteenth century there was a small amount of unorganized exportation, chiefly through purchases by tourists and travellers.

By 1910 a small movement had begun to develop an organized business in the shipping of lauhala products to the mainland, as there was a belief that it "should become an industry in these Islands" by using the labor of women at home and children in the schools.<sup>1</sup> In that year (1910) special efforts were put forth in this direction and as a result some \$6,798 worth of articles made of lauhala were shipped to the mainland. Subsequent years,

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<sup>6</sup>Information furnished by Mr. Richard A. Cooke.

<sup>1</sup>Thrum's Annual 1911:38.

however, did not keep up that standard, though small amounts were shipped continuously. It should be noted that the following table of figures does not indicate the full extent of this industry, for sales within Hawaii are several times as great in the total amount as the reported exports:

#### EXPORTS OF LAUHALA PRODUCTS

<i>Year</i>	<i>Value</i>	<i>Year</i>	<i>Value</i>
1912.....	\$ 894	1922.....	\$2,172
1913.....	1,113	1923.....	756
1914.....	1,187	1924.....	1,658
1915.....	819	1925.....	1,192
1916.....	722	1926.....	1,851
1917.....	550	1927.....	2,099
1918.....	203	1928.....	1,698
1919.....	320	1929.....	2,540
1920.....	1,775	1930.....	2,038
1921.....	4,017	1931.....	2,221

At the present time there is a strong effort being put forth by the Hawaiian Board of Missions to stimulate a revival of this ancient art among the Hawaiian families living in certain rural areas where the hala trees are especially abundant, as in Puna and Kona, etc. It is believed that a lucrative, though small, industry can be fostered which will appreciably augment the income of many rural homes. It is said that some 200 families are now engaged in this industry and the market for the products is steadily expanding.

#### HAWAIIAN RASPBERRY See "Akala."

**HEMP** Hemp (*Cannabis sativa*) is a temperate zone plant of the milkweed family. The fibers of its stems constitute the hemp of commerce, used extensively in the making of rope, twine, laces and many other things. In its leaves and flowers there is a drug, known as hashish or marijuana, which in some countries is the source of some revenue and much evil.

Until recently, the making of hemp fiber has required a great deal of tedious human labor and, consequently, it was chiefly in countries of low wage standards that the industry developed. India, especially, has long been noted for its production of hemp fiber, as well as hashish. In recent years, however, American inventiveness has developed machines which harvest and lay out the hemp

plants for retting and later gather and clean the fiber. This has made possible the development of a hemp fiber industry in those sections of the United States where climatic conditions are favorable, as in the northern Mississippi Valley states.

Hemp culture has recently been given a limited trial in Hawaii, seed having been obtained by the Agricultural Extension Service a year ago. Plantings at Hanalei and Kapaa on Kauai and at Makawao on Maui showed poor results.

Several other fiber plants are commonly called hemp: manila hemp, a relative of the banana (see "Manila"); sisal hemp, a kind of century plant, or Agave (see "Sisal"), and malina, which is a closely related species (see "Malina"); sunn hemp, a leguminous plant (see "Sunn Hemp"), and bowstring hemp (see "Sansevieria").

**HEVEA** See "Rubber."

**HIBISCUS** The hibiscus,<sup>2</sup> official flower of Hawaii and most lovely of all her ornamentals, may scarcely be considered to be of commercial importance except possibly as an article of sale by nurseries. The poor keeping qualities of the flowers and their omnipresence in all yards and at all times of the year have prevented the development of a regular market for the hibiscus. From the esthetic point of view, however, this garden plant has very great value not measurable in dollars and cents.

There are many householders and some horticulturists who find a pleasant avocation in the breeding of new hibiscus varieties by cross-pollination, with the result that there are now many thousands of named varieties.

The earliest of these originators was Valentine Holt who in 1910 to 1914 as a specialist at the Hawaii Experiment Station introduced some new types from abroad and by crossing had over 1,000 different varieties, some of them exceedingly beautiful. In those years the Station distributed about 150,000 cuttings of hibiscus for home beautification.

For detailed information as to culture, propagation, cross-pollination and other subjects, the reader is referred

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<sup>2</sup>The principal parent species of the many hybrids in Hawaii is *Hibiscus rosa-sinensis*.

to Bulletin 29 of the Hawaii Experiment Station. Also, see Hawaii Exp. Sta. Annual Reports 1911:41; 1912:43; 1913:26; 1914:31.

**HILO GRASS** Hilo grass (*Paspalum conjugatum*) has been in Hawaii since 1840, or earlier, and is very widely distributed and abundant. As a pasture grass it is considered relatively inferior, to be used only until better kinds can be established.

Ref.—Haw. Exp. Sta. Bul. 65:32, 1933.

**HOGS** See "Swine."

**HONEY** See "Bees."

**HONEY-DEW MELON** This horticultural variant of the cantaloupe and muskmelon is produced to a very limited extent in Hawaii. See "Cantaloupe."

**HONEYWORT** Honeywort (*Cryptotaenia canadensis*) produces scented foliage somewhat resembling celery leaves in appearance. The leaves are used as a condiment in soup, or as greens. Production is very limited, chiefly in the upper ends of the valleys near Honolulu.

See also "Truck Crops."

**HONOHONO** Honohono (*Commelina diffusa*) is an astonishingly rapidly growing grass-like plant which is much used in Hawaii as a feed for livestock, particularly dairy cattle.

Some tests have shown that under favorable conditions an acre of this grass may yield over 200 tons of green matter per year, equal in feeding value to about 40 tons of green alfalfa.

Honohono grows wild in many places and is used both as pasturage and as a source of cut feed delivered to the dairy barn. As its feed value has been considered questionable by some dairymen, the belief being that it causes a lowering of the butterfat content of the milk, a test was made at the University Farm in 1925. The results justified the use of this common weed as a dairy feed, for the butterfat content seemed not to be adversely affected by its use. The principal item of cost in using this feed is the expense of cutting and transporting it to the dairy. As it grows usually in swampy regions it may be a poten-



tial source of liver-fluke infection in the dairy herd.

Ref.—Haw. Exp. Sta. Annual Report 1915:51; U. H., Agr. Dept. Annual Report 1925:19.

**HORSE RADISH** The horse radish (*Armoracia lapathifolia*), the root of which is used in the making of a spicy relish, is produced but sparingly in Hawaii, notwithstanding the fact that it grows readily and yields well.<sup>3</sup> The consumption demand here is very limited.

See also "Truck Crops."

**HORSES**<sup>4</sup> The first horses to be brought to Hawaii were imported in 1803 by Richard J. Cleveland who secured these animals in California. By 1851 the number had increased to about 12,000, but comments by agricultural observers in those days as reported in the Transactions of the Royal Hawaiian Agricultural Society indicate that probably not more than half of them were used for any worthwhile purpose and were probably more of a liability than an asset to their owners.

Thoroughbred horses were imported from England, probably by way of Australia, about 1870, and Aubrey Robinson brought in Arabians from India and Arabia in 1884.

Horse racing became popular in the Islands about seventy years ago and a race track was established in Kapiolani Park about 1872 and continued in use until about fifteen years ago. In the days of King Kalakaua a race track was maintained at Waimanalo. Racing fostered a new interest in horses, and animals of excellent breeding were brought to Hawaii. The interest in racing has, however, declined in Hawaii as it has on the mainland and at present race tracks in the Territory are limited to one at the Maui fairgrounds and another track for training purposes on the Parker Ranch.

Polo continues a popular game in the Territory and excellent polo ponies have been produced and matches are held each year, notably between teams from Maui, Oahu, and the Army.

In former days, overseers on plantations used light horses almost entirely in getting about to supervise their

<sup>3</sup>Krauss, U. H. Agr. Ext. Bul. 16, p. 136.

<sup>4</sup>This statement was prepared by Prof. L. A. Henke.

work but with the advent of motors and better roads on the plantations, automobiles are being more generally used for this work.

The light horses of the Islands are largely of thoroughbred breeding including some Arabians and American Saddle Horses.

Draft breeds have never been numerous, most plantations preferring mules for heavy work. Percherons probably lead among the draft breeds and many Percheron mares are used for mule production, notably on the Parker Ranch.

Practically all of the larger beef ranches maintain and produce some horses and offer their surplus for sale to "riding academies," of which there are several in Honolulu, and to other purchasers. Some of the better racing horses and polo ponies are sold on the mainland. In former years when the U. S. Army maintained a cavalry division in Hawaii, many locally produced horses were sold to the government.

The automobile and tractor have caused a large decrease in the number of horses in Hawaii, as indicated in the following tables:

*Horses in Hawaii*

1900 .....	12,982
1910 .....	15,856
1920 .....	24,307
1930 .....	15,797

*Importations of Horses*

1921-25 .....	366
1926-30 .....	497
1931-35 .....	147

Parasites affecting horses in Hawaii are listed in Haw. Exp. Sta. Annual Report 1936:82.

**HUBAM CLOVER** Hubam clover (*Melilotus alba annua*), a hybrid variety, is a temperate zone soiling and fodder crop which attracted much attention on the mainland a few years ago. It was given a trial here but the results were not promising.

Ref.—U. H. Agr. Dept. Annual Report 1922:18.

**INDIGO** The indigo plant (*Indigofera suffruticosa*), cultivated in the East Indies and other tropical countries

for a dye which is expressed from it, was introduced into Hawaii in 1829 by Dr. A. P. Sevier<sup>1</sup> with the idea that it might become the basis of an industry here. Its cultivation was not taken up, but nevertheless it became established in the wild state.

Some years later, a chemist, D. Frick, made some studies of the wild growth and reported<sup>2</sup> some good possibilities of establishing an indigo industry in these Islands, using either the wild plants or returning them to cultivation. The Royal Hawaiian Agricultural Society appointed a committee to study<sup>3</sup> the chemist's recommendations and eventually a half-hearted endorsement was given, indicating that a moderate profit might be realized in manufacturing indigo from the wild plants, but if an effort should be made to develop the industry on the basis of cultivation the committee expressed the "fear that the very high price of labor would nearly, if not entirely, absorb all the profits."

Notwithstanding this report, Frick himself undertook to establish an industry by building a small plant in Nuuanu Valley. After nearly a year's trial he gave it up because of his inability to find a buyer for his product. No one in Hawaii or California was interested in buying, and he had insufficient capital to push his experiments further.

Many years later, in 1895, the growing of indigo was urged as a rotation crop on sugar lands. It was pointed out that some thirty years prior to that time "the Island of Oahu was overrun with wild indigo" and that cattle finally exterminated it by eating and trampling it.<sup>4</sup>

**IRONWOOD** The ironwood tree (*Casuarina*, several species) is an introduction from Australia. It is a valuable addition to our list of trees, especially for the lowlands near the sea. It grows very rapidly and produces good fuel wood, one record on Kauai showing 65 cords per acre in 19 years of growth.<sup>5</sup>

The ironwood is useful, also, in windbreaks and as a

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<sup>1</sup>Trans. Royal Haw'n Agr. Soc. Vol. I, No. 1, p. 53.

<sup>2</sup>Same, Vol. II, No. 2, p. 79.

<sup>3</sup>Same, Vol. II, No. 2, p. 82-3 (1855).

<sup>4</sup>Planters Monthly Vol. XIV, p. 486 (1895).

<sup>5</sup>Haw. For. Agr. 1915:208.

forest cover in the lower foothills where rainfall is not very abundant.

Ref.—Planters Record II, 1875 VI, 71, 77.

**JACK BEAN** The jack bean or sword bean (*Canavallia ensiformis*), has been used advantageously as a soil-ing crop in Hawaii.

Ref.—Planters Record (H.S.P.A.) III, 54.

**JACK FRUIT** The jack fruit (*Artocarpus integrifolia*) is similar in some respects to the breadfruit, which see; it is much less edible and is very uncommon in Hawaii.

**JAMBOLAN PLUM** See “Java Plum.”

**JAPANESE PLUM** See “Loquat.”

**JAVA PLUM** The Java plum (*Eugenia Jambolana*), sometimes called jabolan plum or Portuguese plum, is a native of southern Asia. It was introduced into Hawaii many years ago for use as an ornamental and has established itself in the wild state in many localities throughout the Territory, bidding fair to become something of a nuisance because of the ease with which the seed is disseminated by mynah birds. The fruits are about the size and appearance of a small, purplish-black plum; although edible when thoroughly ripe, very little use is made of the fruit. Efforts should be made to discover any potentialities in it for commercial exploitation, since it is becoming so abundant.

**JELLY MAKING** There are many kinds of fruits in Hawaii suitable for use in the making of jellies and preserves on a commercial basis. A list would include the following:

Akala	Ohelo
Carambola	Orange
Carissa	Papaya
Guava	Pineapple
Java plum	Poha
Jujube	Roselle
Kumquat	Surinam cherry
Loquat	

For detailed directions for the making of jellies and jams consult Bulletin 47 of the Hawaii Experiment Station.

**JERUSALEM ARTICHOKE** The Jerusalem artichoke (*Helianthus tuberosus*) is a sunflower, not an artichoke. It is of commercial importance due to the fact that its tubers yield levulose, an uncommon kind of sugar which commands a relatively high price in the market because of its rarity.

The U. S. Department of Agriculture has been for several years promoting the cultivation of this plant in various parts of the mainland for its commercial value as a source of sugar, with only moderately successful results. Trials have been made in Hawaii by the H.S.P.A. Experiment Station, but without practical success. The tubers grow readily enough here and produce vigorous plants, but the propagation from one planting to the next is difficult because of the fact that the tubers seem to require a resting period between seasons. The equable climate of Hawaii causes growth activities of the plant to be continuous, with no period of rest. It is said, too, that termites attack the tubers and destroy them.

A much more promising source of levulose in Hawaii is the common ti, which grows abundantly throughout the Islands.<sup>1</sup> See "Ti."

**JESUIT NUT** The Jesuit Nut (*Trapa bicornis*) is a floating aquatic plant which produces a nut-like seed used by the Chinese in certain festivals. Its consumption here is very small and its production limited.

Ref.—Haw. Exp. Sta. Bul. 60:41, 1929.

**JUJUBE** The jujube (*Zizyphus Jujuba*) is an Asiatic fruit, sometimes called Chinese date. It came to Hawaii from China many years ago. It is a small tree which produces yellow fruits about the size of a cherry or date, much prized by the Chinese for the making of condiments and preserves.

It is grown chiefly as an ornamental in Hawaii and is comparatively rare.

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<sup>1</sup>Information concerning these trials was obtained from Dr. H. L. Lyon, Director of the H.S.P.A. Experiment Station.

In California this fruit is processed in sugar syrup to give it a consistency similar to that of the dried date and in this form it is finding favor to an increasing extent. It is possible that an industry might be developed here on this basis, using some of the more arid areas for its cultivation, as the Lualualei homestead district near Waianae (Oahu).

**KALE** Kale (*Brassica oleracea acephala*) is a relative of cabbage but does not form a head; its succulent leaves are cooked as greens. It is not commonly produced in Hawaii, but occasionally may be found in truck gardens.

**KAMANI** There are two different species of tree called kamani. One, *Terminalia cattapa*, is a familiar shade tree with fruits which are shaped somewhat like an almond nut, hence the name "tropical almond." The kernel of the seed is edible, either raw or roasted, but no commercial exploitation of this product has been developed.

The other, *Calophyllum inophyllum*, probably has a better right to the name "kamani," as it has been in the Islands for many hundreds of years. Its fruits are globular and not good to eat.

Ref.—Wilder, "Fruits of the Hawaiian Islands" (1911), pp. 150-153.

**KAPA** See "Tapa."

**KAPOK** The kapok, or cotton tree, (*Ceipa pentandra*) is a large tree which produces seed pods filled with light, silken fiber which is sometimes used for commercial purposes, as for stuffing pillows, mattresses, life-preservers, etc. There are a few specimens of this species in various parts of the Territory, introduced by the Board of Agriculture and Forestry, but growth has been only moderately good, indicating that climatic and other conditions are not ideal. No commercial use has been made of them.

**KARBOTEX** See "Bagasse."

**KIAWE** See "Algaroba."

**KIKUYU GRASS** Kikuyu grass (*Pennisetum clandestinum*) was introduced into Hawaii in 1924 by F. G.

Krauss. It is proving to be very valuable and its use is spreading, especially in dairying regions.

Ref.—Haw. Exp. Sta. Bul. 65:38, 1933. Also, U. H. Agr. Dept. Annual Report 1929:55.

## KING ORANGE See "Mandarin Orange."

**KLU** Klu is the Hawaiian name for a very common leguminous shrub (*Acacia farnesiana*) which grows freely in arid waste places. In India it is known as "cassie." Its flower is valuable as a source of perfume and in India is an article of commerce, commanding 50 to 75 cents per pound when dried.

The Hawaii Experiment Station in its first year of operation (1901) called public attention to the klu flower as a possible source of new revenue in these Islands, but little effort has ever been put forth as a result to develop this wild "crop." A few tests have been made of the perfume content of the Hawaiian klu, and these give indications that the flowers here are quite equal to and perhaps even a little better than the India product.

As a source of honey the klu has a small value, but far less than the algaroba.

Ref.—Haw. Exp. Sta. Annual Report 1901:377.

**KOA** The koa (*Acacia Koa*) is a native of Hawaii and once comprised a large part of the forest cover here. The wood is used for furniture, cabinet work, ukuleles, etc. A quarter century ago and earlier it was taken from the forests more extensively than now, and was marketed under the trade name "Hawaiian Mahogany."

See "Forest Products," also, "Tan-bark."

**KOA HAOLE** Koa haole, ekoa, or false koa (*Leucaena glauca*) is a very widely distributed shrub or small tree which grows wild in dry localities where little else will grow. Its foliage and pods are eaten by livestock and have a very high nutritious value, as the plant is a member of the leguminous family. Chemical analyses in the University laboratories indicate a high protein content, 6.74 percent in the fresh state and over 24 percent in dried material.

It should not be used as a feed for horses as it causes the tail to shed its hairs badly.



For cattle and hogs it is a very valuable feed, because it is both nutritious and cheap. If dairy cattle are fed *exclusively* on koa haole the milk acquires a disagreeable flavor, but when used in a mixture with several other feeds, the milk flavor is not affected.

As a source of fiber this plant is said to have some value.

Ref.—U. of H. Agr. Dept. Annual Report 1929:11.

**KOHLRABI** The kohlrabi (*Brassica oleracea Caulo-Rapa*), is a member of the mustard family which provides man with many food plants. The edible portion of the kohlrabi is the fleshy, succulent petiole and midrib of the large leaves.

Production of this plant in Hawaii is very limited, as the demand is not great. Some market gardeners devote small areas to its production, the aggregate of all probably being less than 5 acres.

See also "Truck Crops."

**KOLA** The kola nut (*Sterculia acuminata*) is the source of a drug containing caffeine. The tree is a native of Africa. In 1884 an effort was made to establish the production of the kola nut as an industry in Hawaii, for the market was then offering \$400 to \$500 per ton for the nuts. A small quantity of seed was obtained from Africa by Mr. A. Jaeger and planted at Ulupalakua (Maui), but nothing of commercial importance seems to have resulted. Mr. C. S. Judd believes none of these trees is living today.

Ref.—Planters Monthly Vol. III, p. 515 (1884); XV, p. 477-480 (1896).

**KUDZU** The Kudzu (*Pueraria thunbergiana*) is a perennial vine which is sometimes grown for ornamental purposes in Hawaii. Its roots become greatly enlarged, resembling a sweet potato in general shape, but in texture being coarser and more fibrous. Although full grown root enlargements may attain a length of two feet and a diameter of twelve to eighteen inches, it is only the young roots that are fit for use as food. The older, larger roots are sometimes used in the manufacture of starch.<sup>1</sup>

<sup>1</sup>Haw. Exp. Sta. Bul. 60, p. 52, 1929.

**KUKUI** The kukui tree (*Aleurites moluccana*), widely distributed throughout the South Pacific and southern Asia, has been in Hawaii for many centuries, probably having been brought by Polynesian immigrants. Its light green foliage is a distinctive feature in the lower forests, especially in areas where rainfall is ample. The tree produces large quantities of oil-bearing nuts which are enclosed in a leathery husk. At maturity the nuts drop from the tree and soon the outer husk sloughs off, leaving a hard-shelled nut which encloses the oily kernel.

Hawaiians long ago discovered two uses for the nuts: as a condiment with their meals, and as a means of illuminating their houses. Small quantities of the kernels ground into a coarse meal were found to be wholesome, probably because of the laxative effect. Illumination was secured by "stringing" the nuts in a row on a green stick and igniting them, or by crushing the nuts and igniting the oil. From this use they have come to be called the "candle-nut."

The oil of various species of *Aleurites* has been used by man for many centuries, as food sometimes but much more commonly for oiling paper and wooden surfaces. Like linseed oil, it dries quickly and therefore is particularly valuable for protecting the surface of wood. When, therefore, foreigners came to Hawaii and found great quantities of these nuts available for the gathering, efforts began to be put forth to take advantage of the situation. Crude presses were made for expressing the oil and from time to time some hundreds or a few thousand gallons were shipped out to the United States. One report<sup>2</sup> has it that exports reached an annual maximum of about 10,000 gallons between 1840 and 1850, all manufactured by very crude methods.

In 1855 a chemist by the name of Frick<sup>3</sup> undertook to devise an improved type of machine for expressing and refining the oil and reported to the Royal Hawaiian Agricultural Society that he believed he had solved all the problems and could show the way to establishing a good industry in manufacturing this oil either for paint pur-

<sup>2</sup>Haw. Agr. Exp. Sta. Press Bul. 39, p. 2, 1913; see, also, Thrum's Annual 1913:150.

<sup>3</sup>Trans. Royal Haw'n Agr. Soc. Vol. II, No. 3, pp. 101-103.

poses, soap making or for culinary use. The annual crop of nuts continued to fall unused, however, for Frick's plans were not put to practical use.

In 1913 the Hawaii Experiment Station had its attention drawn to "the enormous quantities of kukui nuts going to waste throughout the Islands" and began a study of the problem. A bulletin was issued<sup>4</sup> reviewing the existing knowledge on the subject, and offering an estimate that about 15,000 acres of mountain land was occupied by kukui, of which at least 10,000 would be accessible for gathering the nuts for commercial use; further, that the average yield of nuts should be about 5 tons per acre per year, and that these 50,000 tons of nuts when gathered and put through the presses should yield 2,375,000 gallons of oil.

Paint and varnish companies in the United States were at that time becoming interested in the possibilities of producing this oil in America in order that they might obviate the uncertainties of dealing with such a distant country as China. The Chinese tung oil, or wood oil, made from *Aleurites fordii* in China, was considered better than kukui oil, and extensive plantings of the Chinese species were being made in Florida and other southern states. While they preferred the tung oil, these manufacturers were interested, also, in Hawaiian kukui oil and for several years made various gestures calculated to stimulate a greater effort here at developing a large industry.

The chief obstacle seemed to be the cost of gathering the nuts. At prevailing prices for the oil, \$1.50 per day was about all that could be paid for the labor of gathering nuts in the forests and that was apparently not enough to attract the response that was hoped would come when various firms and individuals at one time or another offered to buy nuts delivered to a factory.

When it was found that tung oil produced from *Aleurites fordii* is better for paint and varnish manufacture than the Hawaiian kukui oil, *Aleurites moluccana*, but that the latter species bears more heavily than the former, efforts were made by the Hawaii Experiment Station to cross-pollinate the two in the hope that the good qualities

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<sup>4</sup>Press Bulletin 39.

of both might be consolidated into one hybrid type of tree.<sup>5</sup> Thus far nothing of commercial importance has resulted from these efforts.

Several experimental plantings of the tung oil tree (*Aleurites fordii*) have been made in Hawaii, some by the Board of Agriculture and Forestry and some by individuals, as for example Mr. Pauls who has a small grove in Kona (above Keauhou). This tree grows best in a temperate zone climate where the nights are cold and frosts occur, and therefore in Hawaii only the upper elevations, above 4000 feet, should be considered. Such areas are usually difficult of access, the general terrain being mountainous and rough; thus, not only would the planting and cultivation be more expensive than on flat land, but the gathering of the nuts and transporting them to a factory would be relatively expensive. Florida is using large stretches of level lands for this tree, where it is possible to use machine methods on an economical basis.

By developing a hybrid type of tree which would bear abundantly the preferred kind of nut and would grow well in areas more accessible to being worked than the higher mountainous regions just mentioned, it might be possible to develop an industry on this commodity. At best, however, the prospect is not as attractive as that offered by certain other crops.

Ref.—For a full treatise on the history and chemistry of these oils see Press Bulletin 39 of the Hawaii Experiment Station. Also, see "Tung Oil," a mimeographed bulletin issued in 1935 by the U. S. Department of Commerce, Washington, D. C. (no ref. number). Brief references in Haw. Exp. Sta. Annual Reports 1913:34; 1914:19; 1915:25. Haw. For. Agr. 1917:127-129; 1919:222-223 (good statement by C. S. Judd).

**KUMQUAT** The kumquat (*Fortunella japonica*) is a member of the large group of citrus fruits. It is a shrub or small tree, useful as an ornamental, and produces an abundance of small, golden fruits resembling a sour orange in flavor and structure, but only an inch or less in diameter. The fruits are used sometimes in the making of preserves and marmalade. Although the kumquat grows very well in Hawaii and occurs not infrequently in gardens, it is not exploited commercially.

<sup>5</sup>Haw. Exp. Sta. Annual Report 1915:25.

**LANZON** The lanzon (*Lansium domesticum*) is a fruit tree occurring in the Philippine Islands and introduced for trial in Hawaii some twenty years ago by J. E. Higgins. The fruit resembles the loquat in appearance, except that it is smooth on the outer surface, lacking the fine hairiness characteristic of the loquat; in flavor it is suggestive of the grapefruit.

The early trials were not successful but new plantings are now being made in Kona by the Experiment Station. Ref.—Haw. For. Agr. 1922:269-270; Haw. Exp. Sta. Annual Report 1936:95.

**LAUHALA** See "Hala."

**LEAF-MUSTARD CABBAGE.** This Chinese plant (*Brassica juncea*) is a species of cabbage but does not form a head. It is cooked and eaten either in the very immature stage when little more than a seedling or when it is about half grown to maturity. In the latter form it resembles Chinese cabbage in many respects. It is occasionally found in truck gardens but total production is much less than of Chinese cabbage.

See "Chinese Cabbage," also "Truck Crops."

**LEATHER** Although good tan-bark, lime and other ingredients necessary for transforming animal skins into leather were at hand, the Hawaiians had not discovered and developed the art prior to the coming of western civilization in 1779. It should be noted, of course, that they would have had only dog and pig skins to tan if they had developed the art. Early in the nineteenth century, however, the manufacture of leather began on a small scale, but not extensively enough to make importations unnecessary. Toward the middle of the century the Royal Hawaiian Agricultural Society<sup>1</sup> appointed a committee to investigate the possibilities and costs of establishing a leather manufacturing industry here to make use of the abundance of hides which were available. The report of the committee indicated that the opportunity was good, but the requisite determination on the part of the local population was lacking. It was pointed out that over \$100,000 worth of leather goods were imported each year and that leather

<sup>1</sup>Trans. Royal Haw'n Agr. Soc. 1853, p. 86.

fully equal in quality to anything made elsewhere was being made here, but the stimulus was not enough to set an industry in motion. One of the obstacles noted at that time (1853) was the cost of obtaining tan-bark. The local chieftains were charging heavily for permission to gather the bark in the forests and the cost of the labor of gathering it was relatively high, making it more expensive to tan leather here than to import it.

In 1905 the Metropolitan Meat Co. established a tannery in Honolulu (Kalihi) and brought an expert from Boston to operate it. A good plant was built and a diligent effort put forth to secure at least the local trade in leather with such additional business as could be secured in the Orient and on the mainland. It developed, however, that the costs of tanning here were higher than had been expected and it seemed impossible to meet mainland prices. In 1909 the tannery was closed.

At present there is practically no manufacture of leather in the islands except on a small scale at some of the cattle ranches where a home supply is desired for miscellaneous purposes.

See also "Tan-bark."

Ref.—Trans. Royal Haw'n Agr. Soc. 1853, p. 86; Haw. For. Agr. 1905, 223-226.

**LEEK** The leek (*Allium porrum*) is a close relative of the onion and is used in the same manner as "green onions." Many truck gardens near Honolulu and Hilo produce limited quantities of this vegetable. In crop surveying it usually passes as a variety of onion.

See "Onion" also "Truck Crops."

**LEMON** The common lemon of commerce (*Citrus Limonia*) seems to be better adapted to sub-tropical situations such as in Southern California than to the warmer tropics. In Hawaii there have been a number of efforts made on a limited scale to grow lemons on a commercial basis but with no great success. Production is usually light<sup>2</sup> and the acidity of the fruit is lower as compared with regions where this fruit is at its best. The total area

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<sup>2</sup>A few trees of Eureka and Villa Franca lemons grown at the Hawaii Experiment Station grounds were reported in 1916 (Annual Report, p. 19) to be bearing "heavily." Mr. Jared Smith states that in 1901 he saw heavily bearing trees in the Olaa coffee homestead area.

devoted to lemon production in this Territory is less than five acres. For Hawaii there is a better prospect of success in the commercial growing of limes.

A variety of "rough" lemon grows well here and is occasionally found in gardens but its fruits are not as desirable as the common lemon for the juice is bitter. Seedling trees of this variety are sometimes used as budding or grafting stocks for propagating orange and other kinds of citrus trees for commercial planting.

See "Citrus Fruits" also "Limes."

Ref.—Haw. Exp. Sta. Bul. 77:43 (uses of lemon).

**LETTUCE** Lettuce (*Lactuca sativa*) has for many centuries supplied the need for leafy food in many countries but in early Hawaii this need was filled by the taro leaf and lettuce was unknown until the foreigners brought it at about the beginning of the nineteenth century. At first grown only in home gardens it later became the basis of a small industry for supplying local needs. For many years only the leafy types, such as the mignonette, were grown for it was believed that the heading types would not do well in these tropical surroundings.

When modern transportation facilities began to be available head lettuce together with other kinds of vegetables, was imported from California to satisfy the demands of Americans and Europeans resident here. The Orientals preferred the open leafy types, and to a considerable extent the Occidentals used this type, also, so that small truck gardens continued to flourish in areas near a city or town.

In the early 1920's some Japanese gardeners in the vicinity of Kilauea Volcano, at an elevation of about 3,000 feet, began experimenting with head lettuce and succeeded in growing a very excellent product, quite equal to anything that came from California. The Agricultural Extension Service took note of this and stimulated the expansion of the incipient industry. In the course of the next several years it spread to the Waimea district of the same island and to the Kula district of Maui, the total area planted never amounting to over 50 acres, however. Excellent lettuce is raised here when weather conditions are favorable; in these areas mentioned the farmers have to depend on rainfall, as irrigation water is not available.



In 1925 the Hawaii Experiment Station began a project to develop by hybridization and selection a variety of lettuce that would grow well and form a firm head in low-land areas. This was carried on for five years with practically no success even though a thousand or more crosses were made. The plan was finally given up.

In some cooler upland areas where there is adequate rainfall or available irrigation water it should be possible to develop a profitable industry in the growing of head lettuce for the Honolulu market and for other towns in the Territory. How extensive this might become is difficult to estimate; probably it could not be developed beyond a few hundred acres of planting.

For detailed information on cultural practices, varieties, marketing, etc., consult the extension bulletin mentioned below, published by the University in 1932.

Ref.—Agr. Ext. Bul. 16:95-104, 1932 (by F. G. Kräuss); Haw. Exp. Sta. Annual Reports 1925:10; 1926-12; 1927:14; 1928:18; 1930:8; 1936:24.

**LEVULOSE** See "Dahlia," "Jerusalem Artichoke," "Ti."

**LILIKOI** See "Passion Fruit."

**LIMA BEAN** The lima bean (*Phaseolus lunatus*), sometimes called "butter bean," is the largest of the cultivated beans. The plant is of two types, bushy and climbing vine, the large flat pods being produced in abundance under proper cultivation.

A recent crop survey (1936) shows an aggregate of about 50 acres devoted to the production of lima beans for the local market, nearly all of which acreage is on Oahu, scattered in small units in many truck gardens. In addition to this production there are considerably larger amounts of dried lima beans imported from the mainland.

See also "Beans" and "Truck Crops."

Ref.—U. H. Agr. Ext. Bul. 16:60, 1932.

**LIMES** The acid lime (*Citrus aurantifolia*) is a tropical species and thrives very well in Hawaii, much better than the lemon. Its fruits are more acid than the lemon, very juicy, and possess an aroma and flavor more pleasant than that of the lemon. In spite of this, however, the quantity of imported lemons consumed far surpasses the

amount of limes produced here, the total acreage of the latter being less than ten acres, according to a recent (1936) crop survey.

There are several varieties of limes here, the commonest being the Kusaie, introduced many years ago from the South Pacific. Another, the Mexican lime, was introduced in 1920 by D. L. Crawford and is found occasionally in Kona. Either of these varieties would be suitable for planting on a large scale, if it should be considered possible to market the crop as a substitute for imported lemons.

See also "Citrus Fruits."

Ref.—Haw. Exp. Sta. Bul. 77:44 (uses); see also Planters Monthly XII, 286 (1893).

#### LINSEED OIL See "Flax."

**LITCHI** The litchi<sup>3</sup> (*Litchi chinensis*), well known in Hawaii as a delicious and somewhat rare fruit, is beginning now to be cultivated on a much larger scale and may become an important factor in the diversification of industry here.

It was brought to these islands in 1873 from southern China,<sup>4</sup> where it has been cultivated for many centuries. In spite of very high prices paid for the fruit (50 to 75 cents per pound) its production has always been limited in Hawaii, probably because of the difficulty of propagation. While it grows readily from seeds, the seedlings are usually valueless and vegetative propagation has to be resorted to. The Chinese method of doing this has been by a process known as "air-layering." A branch while still attached to the tree has a bit of bark removed and is then encased in a ball of earth which is kept continually moist. In the course of a few months roots develop in this soil and the branch is then detached from the tree and planted.

After its first introduction here some attempts were made to establish its cultivation on an orchard basis, but several large lots of young trees imported from China died on the way or soon after arrival, causing the abandonment of the plans for commercial exploitation of this fruit.

The litchi was among the first fruit trees to be planted by the Hawaii Experiment Station shortly after its estab-

<sup>3</sup>Pronounced lye-chee.

<sup>4</sup>Hawaii Exp. Sta. Bul. 44, p. 5.

lishment in 1901. The initial plantings produced abundant crops of fruit at least as early as 1914, and attempts were then made to propagate the trees by budding and grafting. The grafts made at that time failed to take when made on litchi stocks but did take when placed on stocks of the longan, a closely related species. A few years later, however, in a wind storm these grafts were blown off at the point of union, due apparently to some inherent weakness in the union. About 1931 the Station succeeded in developing a technique whereby it is possible to graft small seedlings of the litchi with scions from mature litchi trees. There has been insufficient time, however, to demonstrate the bearing qualities of these recently grafted seedlings.

The fruit is most commonly known in the dried form, called "litchi nut," but in the fresh state or canned in juice it is even more delicious. Some of the canned product from China enters the American market and meets a good response, as a novelty. This is encouraging certain individuals here to try to develop a litchi canning industry on modern American lines, for it is believed that the conditions in Hawaii are ideal for this. The climate and soil are suitable, and there seems little doubt but that there is an extensive market for the product. The problem now is how and where to obtain enough young trees for planting.

Ref.—Haw. Exp. Sta. Bul. 44, "The Litchi in Hawaii," 1917; Bul. 77:45-47 (uses and recipes); Annual Report 1915:20; 1916:16; 1919:29; 1921:22; 1925:7; 1930:30; 1936, 9, 26, 28, 95.

**LIVESTOCK** Industries of various degrees of importance to Hawaii have developed around the following members of the animal kingdom, loosely grouped together as "livestock":

- Beef cattle
- Bees
- Dairy cattle
- Goats
- Horses
- Mules
- Poultry (chickens, ducks, geese, turkeys, etc.)
- Rabbits
- Sheep

**LONGAN** The longan (*Euphoria longana*) is a Chinese fruit, sometimes called dragon's eyes, which is closely related to the litchi (which see) and is only rarely grown in Hawaii.

Ref.—Haw. Exp. Sta. Annual Report, 1936:28.

**LOQUAT** The loquat (*Eriobotrya japonica*), sometimes called Japanese plum, was introduced into Hawaii many years ago from the Orient. An early record<sup>5</sup> mentions a single tree of this fruit at Hanalei, Kauai. Home-steaders in the Hamakua section of Hawaii have grown this fruit tree to a limited extent for many years.

Although the fruit is of pleasant flavor and offers some possibilities for commercial exploitation as a source of excellent juice, the loquat is not extensively grown in Hawaii as a fruit tree. A recent crop survey (1936) shows a few scattered plantings to a total of about 4 acres. As an ornamental it occurs not uncommonly in gardens, and as a forest tree it is used at the lower and intermediate elevations; it is propagated there by scattering the large seeds in the mountain forest areas, but only a relatively small number succeed in establishing themselves, as a result of which this tree is not of common occurrence in our forests.

The fruit is subject to attack by the Mediterranean fruitfly, but its structure—a quarter-inch layer of pulp over a large seed—makes it easier of protection by the fruitfly parasites, as compared with the larger fruits like the guava or grapefruit in which the fruitfly worms may be out of the reach of the parasite wasps.

**LOTUS ROOT** The lotus (*Nelumbo nucifera*) is an aquatic plant indigenous in southern China and India. Introduced into Hawaii many years ago by the Chinese, it is in semi-cultivation here, but not extensively.

The edible portion of the plant is the root, which resembles a chain of link-sausages in appearance, the "links" being 3 to 6 inches long and 2 to 3 inches in diameter, connected by a short petiole to adjoining units. A cross-section of the root shows a number of large canals extending in straight lines longitudinally through each link. As the roots are sliced in preparation for being eaten, these canals give the lotus a very distinctive appearance.

<sup>5</sup>Trans. Royal Haw'n Agr. Soc. 1853, p. 94.

The commercial demand for lotus root is mostly from the Chinese, but other people are using it more and more. Some 50 acres in this Territory are devoted to the production of this crop, with some imports coming from China to add to the local supply.

Ref.—Haw. Exp. Sta. Bul. 60, p. 53, 1929.

**LUNGAN** See "Longan."

**MACADAMIA NUT** The macadamia nut (*Macadamia ternifolia*) is a novelty in the American market but seems to offer much promise of becoming an important item in the list of commercial nuts.

This nut grows on a large and handsome tree which is indigenous in Australia and is valuable for its hard wood as well as the harvest of edible nuts. The first introduction of this tree into Hawaii seems to have been in 1892 when R. A. Jordan brought some seeds from Australia, some of which were planted at his Nuuanu Valley home, and some on the slopes of Tantalus by the Bureau of Agriculture of the Hawaiian Government. Some of these trees are still standing. A closely related, but commercially inferior, species (the gympie nut) was introduced about ten years earlier and established in Hamakua.

The trees started as seedlings in 1892 were slow in coming into bearing, perhaps because they were too crowded; in 1908 they began to bear and by 1910 the yield was large enough to attract some interest as a possible new agricultural crop for Hawaii. But it was several years before commercial operations were begun, and then only on a small scale in several parts of the Territory, two areas on Oahu and several on Hawaii.

In 1915 the Hawaii Experiment Station<sup>1</sup> began giving some attention to the problems incidental to the production of this new nut crop. A thousand young seedling trees were distributed in 1918, mostly in Kona where it was believed that conditions were ideal for such an industry, and a brief circular of information was issued summarizing the existing knowledge concerning cultural

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<sup>1</sup>The Hawaii Experiment Station's lands included the area on which the Bureau of Agriculture of the Hawaiian Government had planted macadamia nut trees in 1892, and it was from these trees that the Station obtained its propagating materials.

practices, processing the nuts, etc. A successful method of grafting the macadamia tree was developed later by the Station.

By 1927 the interest in the crop had grown to the point where the Territorial Legislature was willing to exempt all commercial macadamia nut plantings<sup>2</sup> from taxation for five years as a means of helping an infant industry to get a firm footing. In 1929 an excellent bulletin (No. 59) was issued by the Experiment Station on macadamia nut culture.

Meanwhile the commercial plantations were encountering serious difficulties and not obtaining the profitable returns for which they had hoped. A large percentage of the seedlings turned out to be of the "rough-shell" variety which produces a relatively smaller and less oily kernel than the "smooth-shell," and the expense of converting them by grafting seemed too large to contemplate in the depression years. Also, the cost of cracking the nuts, roasting and grading the kernels and marketing the final product proved disturbingly large because of inadequate machinery and the smallness of the total crop. As a result, the retail price of the nuts has been so high that they could not be thought of as competing directly with the more widely established types of market nuts.

A new stimulus came, however, in 1935 when Congress ruled that a portion of the sugar processing tax receipts must be devoted to the diversification of agriculture in Hawaii. The macadamia nut industry has been receiving some of the benefits of this, by the enlarged program of research and experimentation thus made possible.

Recent investigations by the Hawaii Experiment Station have included an examination of over 1,500 individual trees by an expert horticulturist and the selection of some forty-one which are superior in that they have a combination of several desirable characteristics. Chief among these characteristics is thinness of shell of the nut,<sup>3</sup> which is important in two respects: (1) the kernel is rela-

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<sup>2</sup>At that time there were ten plantations of from 1 to 100 acres each, total area of all being about 300 acres, on four islands—Hawaii, Maui, Oahu, and Kauai.

<sup>3</sup>The range of variation can be best expressed in the percentage of the weight of the kernel in relation to weight of the nut, which varies from 18 to 42 per cent.

tively larger, and (2) the cracking of the nut is easier and less expensive. It may be possible to develop a variety with shell thin enough to be cracked as easily as that of the almond or hazel nut. Another characteristic of much importance is richness of oil content. Large kernels are not always rich in oil, a fact which must be taken into consideration in the development of a superior type of tree.

Propagation of many new trees derived from these selected individuals is now under way to ascertain whether or not the desirable characteristics are constant. If so, the desired type of tree will ultimately emerge and may displace present plantings which are very diverse.

After twenty years of effort at establishing an industry on this nut, several points have become clear:

- (1) Hawaii has climatic and soil conditions favorable for its production.
- (2) There seems to be a potential market demand sufficient to warrant developing a large industry, provided total costs can be reduced to make competition with walnuts and pecans possible.
- (3) A suitable type of nut and tree must be developed by further experience, and then vegetative methods of propagation must be used instead of planting seedling trees, in order that the desired type may be had in all plantations. There must be some approach to standardization in this matter through cooperation of all concerned.
- (4) The machinery for cracking and processing the nuts will go through a good deal of evolutionary improvement before the industry is on a sound foundation.

A survey in 1936 indicated that the total acreage planted to macadamia nuts was about 375, with some of the plantings only a year or two old. There is much interest in this crop and it seems destined to fill a much larger place than it now occupies.

Ref.—Haw. Exp. Sta. Bul. 59, pp. 1-23 (1929); Annual Reports, 1919:17; 1920:22; 1921:18; 1922:8; 1923:5; 1927:9; 1928:7; 1930:15, 25; 1936:10, 30-32, 48-50, 93; Thrum's Annual 1928:95-97; Haw. For. Agr. 1923:86-87 (C. S. Judd).



**MAHOGANY** The lumber trade knows several different kinds of mahogany wood, all having in common the characteristics of being very hard, being capable of taking a good polish and being attractively grained. Until recent years the koa was known commercially as "Hawaiian mahogany"; this name is now illegal, however, as a result of efforts of the true mahogany producers to prevent its use for other woods, even when accompanied by a qualifying word, as "Hawaiian."

The true mahogany (*Swietenia mahogani*) is a tropical American tree. It was introduced into Hawaii for experimental planting some years ago and seems to be doing well. The row of trees down the center of Kalakaua Avenue in Honolulu (Waikiki) is of this species, and there is a stand of over 2 acres in Makiki Valley. It is a slow growing tree, valuable chiefly for lumber, and probably not as good for Hawaii as some other kinds of forest trees.

Ref.—Haw. For. Agr. 1918:105. Planters Monthly III, 524 (1884).

**MALABAR CHESTNUT** The malabar chestnut (*Pachira aquatica*) is sometimes used for food purposes but is not considered highly edible. It is a South American plant and was introduced into Kauai some years ago where a very small amount is now cultivated.

**MALABAR NIGHTSHADE** Malabar nightshade (*Basella rubra*) is a vine with somewhat succulent foliage which is cut and folded into neat bundles for market. It is used by the Chinese and Japanese in the preparation of certain meat dishes. Its production is not common nor extensive.

Ref.—Haw. Exp. Sta. Bul. 60, p. 17, 1929.

**MALINA** Malina fiber, called also silk grass, is somewhat similar to sisal but not as strong and not suitable for cordage. It is made from the leaves of a plant (*Furcraea gigantea*) which is thought to have been brought to Hawaii from the Philippine Islands many years ago. This plant is very hardy and although no longer cultivated nor used for fiber making, it may be seen in many dry and barren areas growing wild and apparently thriving. It resembles the agave from which sisal is made

and is commonly mistaken for it; its leaves are less rigid and lack the terminal spine characteristic of the sisal.

There is in malina fiber at best only a moderately good possibility for commercial development in Hawaii, dependent on very cheap land being used and cultivation and manufacturing costs being kept at a low figure. If clearing costs were not too high some of the large areas on the leeward (dry) side of all our islands might be used profitably for production of malina and sisal. Malina fiber has possibilities for paper manufacture.

Ref.—Haw. Exp. Sta. Annual Report 1902:315; Planters Monthly VI, 390 (1887).

**MAMMEE APPLE** The mammee apple (*Mammea americana*) is a tropical fruit tree introduced into Hawaii from the West Indies and used only as an ornamental. In the American tropics the fruit is eaten abundantly, but in Hawaii it is a rarity known to but few people.

The fruit is about the size of a large apple, russet colored on the outside, with a thick, tough rind enclosing a mass of yellow, not very juicy, pulp which is quite edible.

There is no commercial exploitation of this fruit in Hawaii.

**MANDARIN ORANGE** The Mandarin, King orange, or tangerine (*Citrus nobilis*) is a species of orange which thrives well in Hawaii. Its fruit is distinguished from the common orange by the loose bagginess of the skin; the flavor is excellent. It is planted here occasionally in gardens, partly for ornamental purposes and incidentally to furnish a supply of fruits for the household.

See also "Orange."

**MANDRAKE** See "Guava," also "Waiawi."

**MANGO** The mango (*Mangifera indica*), one of the most delicious of all fruits, probably originated in southern Asia but is now common in practically all tropical countries. The tree does not readily adapt itself to the cool climate of the temperate zone and the fruit has been considered too perishable to be shipped long distances to northern cities; for these reasons the mango has never

become well known to the millions of people living outside the tropics.

There is no authentic record of the first introduction of the mango into Hawaii, but Pope<sup>4</sup> believes that Don Francisco Marin is to be credited with having given this luscious fruit its first start here sometime between 1800 and 1820, probably bringing the seed from Mexico. The descendants of Marin's first trees are now scattered all over the Territory and are generally known as the Hawaiian variety, inferior in most respects to some of the varieties more recently introduced. Very susceptible to the fruit fly, this variety is responsible in large measure for the firmness of grip which this insect pest maintains upon the horticulture of these Islands.

In 1885 Joseph Marsden brought in some superior varieties from the West Indies and at various later times others have added still more from India and elsewhere.

A catalog of the many varieties growing in Hawaii is included by Pope in his recent bulletin (No. 58 of the Hawaii Station) dealing with this tropical fruit. These varieties are grouped into six "races," the Hawaiian, West Indian, Alphonse, Sandersha, Mulgoba and Cambodiana. Classification is based chiefly on the characteristics of the fruit—its shape, size, color, odor, fibrousness, flavor, shape of seed, etc. There is a wide range of variation in most of these, causing some to be rated as relatively inferior and others very delectable.

In spite of the fact that the mango has been in Hawaii for over a hundred years and has been well thought of as an edible fruit, it never has achieved for itself a place of any importance in the economic scheme of things here. A recent agricultural survey<sup>5</sup> indicates that the scattered plantings of this fruit, if concentrated into orchard form, would not cover more than perhaps fifty or a hundred acres. This does not take into account thousands of trees of the inferior Hawaiian type growing wild and neglected, and considered of no practical use, except by small boys to whom any mango is a mango, regardless of variety or state of maturity. One of the most valuable of all the plantings is an area of about five acres in the Moanalua

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<sup>4</sup>W. T. Pope, Hawaii Exp. Sta. Bul. 59, p. 2, 1929.

<sup>5</sup>By the Agricultural Extension Service of the University, 1936.

Gardens (Honolulu) where S. M. Damon concentrated many of his importations of the world's leading varieties.<sup>6</sup>

One could suggest several reasons for the failure of this excellent fruit to become the basis of an important industry here. There are serious difficulties incidental to its successful marketing on the mainland, chief among which is the fact that it is almost unknown to the masses of American people and would require an extensive and costly campaign of advertising to establish it well. Also, there are difficulties in shipment; in the fresh state, the perishable nature of the fruit discouraged early efforts, and since 1914 there has been a quarantine prohibition against such shipment because of the fruitfly. Canning the fruit will obviate these difficulties, but the shape and texture of the fruit make it hard to handle for canning. Notwithstanding this difficulty a small canning industry is developing in the Philippines; also, one producer on Maui is growing ten acres of mango trees for the purpose of canning the fruit.

In Queensland, Australia, there is some drying of mangoes for commerce.

It seems quite likely that a profitable industry could be developed here on the mango, if certain superior varieties were used and suitable machinery developed for canning the fruit. There is a limited production in California and Florida and this has made the country sufficiently aware of this tropical fruit to open the way to an extensive market with less advertising than would have been required a decade or two ago.

For detailed information about the propagation and culture of the mango and the control of injurious insects and diseases, the reader is referred to Dr. Pope's bulletin.

Ref.—Haw. Exp. Sta. Bul. 58, "Mango Culture In Hawaii," by W. T. Pope (1929); Bul. 77:48-54 (uses and recipes); Annual Reports 1902:321; 1904:380; 1905:62; 1906:33; 1908:45; 1909:

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<sup>6</sup>Hon. S. M. Damon, who developed his Moanalua estate into a great park and botanical garden, introduced a large number of fruit trees and shrubs from many parts of the world. In 1900 and later he brought here for trial several varieties of Mango: Piri, Alphonse, Cambodiana, Mulgoba and some Philippine varieties; five acres of his estate are devoted to mango culture. Other horticultural importations included several avocado varieties, figs, red banana from Jamaica, grapefruit, grapes and many ornamentals.

Closely associated with Mr. Damon in much of this work was Mr. Donald McIntyre, who is known widely as an expert horticulturist.

For a full account of the Moanalua work, see Thrum's Annual 1914, pp. 75-84.

50; 1910:30; 1911:35; 1912:39; 1915:21, 72; 1916:18; 1919:21; 1920:19; 1921:15; 1922:4; 1923:4; 1924:4; 1925:5; 1926:4; 1927:3; 1928:3; 1936:29; also, Wilder, "Fruits of the Hawaiian Islands" (1911), pp. 132-138; Thrum's Annual 1923:53-64 (W. T. Pope, on possibilities of mango industry); Haw. For. Agr. 1905:116-123 (Donald McIntyre, on culture); 1912:376-377 (dried mango).

**MANGOSTEEN** The mangosteen (*Garcinia mangostana*) is a tropical tree which seems to find Hawaii a little too cool. A few trees are growing here but with indifferent success. As the fruit is exceptionally delicious an effort was made by the Hawaii Experiment Station in 1910 to develop a more hardy form by grafting the mangosteen upon a closely related species which thrives well in these Islands, *Garcinia xanthochymus*, but without success.

Ref.—Haw. Exp. Sta. Annual Report 1910:37; Haw. For. Agr. 1905:91-93 (G. P. Wilder), also pp. 282, 325; 1917:125-126.

**MANILA HEMP** The fiber of a species of banana plant (*Musa textilis*) is known to commerce as manila hemp or abaca, and is used extensively in the manufacture of rope and twine. The United States imports about 40,000 tons per year, mostly from the Philippine Islands. With the increasing use of steel cables, American imports of this article have been diminishing, for the records of a quarter century ago show that 80,000 to 90,000 tons per year came in from the Philippines in an average year.

As this fiber plant requires a tropical habitat and has some considerable economic value, it was long ago (1866) introduced into Hawaii for trial.<sup>7</sup> Experimental plantings were made in Iao Valley on Maui and in Kona (by T. C. White) and in some other places also, but nothing of importance came of these efforts. In 1875 some samples of fiber from the Maui plants were sent to the United States but no commercial development followed. Fiber of good quality was made from the Kona plantings, but only on a small laboratory scale.

The Hawaii Experiment Station in 1903 reported that these plantings were still growing in Iao Valley and other locations, stating that they occurred only in moun-

<sup>7</sup>Thrum's Annual 1904:62.

tain valleys, for the plant requires abundant rainfall and good drainage and will not prosper in wet, swampy soils. The Station made something of an effort to place this before the people of Hawaii as a potential industry for these Islands, publishing a brief bulletin and a number of press releases on the subject. These efforts, however, were fruitless, as was the pioneering work of those who first introduced the plant here, for no industry has thus far developed.

**Banana**—While there is a possibility of Philippine independence giving a new stimulus to the thought of developing a Hawaiian industry in abaca production, it is not highly probable, for the returns are not as attractive as for certain other crops. The average yield could be said to be anywhere from 350 to 1,000 pounds per acre per year, depending on the richness of the soil and the amount of rainfall. It is possible, however, that an industry might be developed in the extraction of fiber from the commercial banana plant, which is closely related to the abaca as hemp species and is known to have a good quality of fiber. As a by-product of a fruit industry such an enterprise should have a better chance for success.

See "Banana."

Ref.—Haw. Exp. Sta. Press Bul. 5; Pac. Com. Advertiser, May 17, 1903; Thrum's Annual 1904:62; Haw. For. Agr. 1904:174-183.

**MANIOC** See "Cassava."

**MATRIMONY VINE** Matrimony vine (*Lycium chinense*) is an Asiatic plant occasionally grown in truck gardens of Hawaii for its leaves, which are used by Orientals in the preparation of certain meat dishes.

Ref.—Haw. Exp. Sta. Bul. 60, p. 18, 1929.

**MATTING SEDGES AND RUSHES** In 1906 the U. S. Department of Agriculture obtained seeds of several species of matting sedges and rushes in the Orient for trial in America. Two of the species, *Cyperus tegetiformis* from China and *Juncus effusus* from Japan, seemed to require semi-tropical conditions and accordingly the seeds were sent to the Hawaii Experiment Station (then under federal control) for trial. Test plant-

ings were made in several localities, as in the swampy area near Kailua (Oahu).

Two years later the Station reported that the Chinese sedge was thriving well, yielding at the rate of nearly ten tons per acre. "The greatest difficulty in the way of making this crop a financial success," the Station Director declared, "consists in the fact that each reed must be split" before being used in the making of matting. The labor cost of this seemed to present an insuperable barrier to commercial success.

The Japanese rush seemed to be of much slower growth and less promising from a commercial point of view.

According to J. M. Westgate, Director of the Station from 1914 to 1935, nothing of economic importance ever developed from these early experiments, and both botanical immigrants joined the limbo of forgotten crops. One of them, the Japanese rush (*Juncus effusus*), has become sparingly naturalized here,<sup>8</sup> occurring here and there in swampy areas, but seemingly being of no commercial value.

Ref.—Haw. Exp. Sta. Annual Report 1908:15, 82 (illustration on p. 80).

**MEADOW RICE GRASS** Meadow rice grass (*Microlaena stipoides*) is found chiefly in Kona where it is proving to be a good range grass.

Ref.—Haw. Exp. Sta. Bul. 65:26, 1933.

**MELONS** Watermelons (*Citrullus vulgaris*) and probably muskmelons also, were introduced into Hawaii by Marin, to whom we are indebted for many horticultural innovations. A member of Captain Cook's discovery crew listed the various food crops found in these Islands in 1778-79 and melons were not among them. In a subsequent inventory, fourteen years later, melons were in the list. Don Marin came to Hawaii first in 1791, and in his journal of 1813<sup>9</sup> he made a record of many kinds of fruits and vegetables which he had "at sundry times" planted since his arrival; among them he mentions "melons," without indicating the kind.

<sup>8</sup>According to Prof. Harold St. John of the University of Hawaii, who reports (unpublished) that it has been collected on the Islands of Hawaii and Molokai.

<sup>9</sup>See Trans. Royal Haw'n Agr. Soc. Vol. I, No. 1, p. 46 (1850).



The watermelon seems to have found a congenial home in these Islands, for it became a common article of garden cultivation in certain localities where the soil was suitable for it, and entered into trade which developed with the whaling ships in the nineteenth century. The Royal Hawaiian Agricultural Society in listing the exports from the Islands in 1850-51 includes an item of 7,756 melons.<sup>10</sup>

Although never assuming important proportions in comparison with the major crops of the Islands, the cultivation of watermelons and muskmelons continued through the century on a scale large enough to fill local needs and to supply ships stopping here. This, however, came to an abrupt end early in the current century when the melon fly (close relative of the Mediterranean fruitfly) gained entrance to Hawaii and proceeded to work havoc with all kinds of melons, squashes, cucumbers, tomatoes and some other crops, causing the U. S. Department of Agriculture in 1913 to lay down a rigid quarantine against the sending of any of these items to the mainland states.

The fact that practically every melon grown became infested with the maggots of this fruitfly discouraged producers and for many years this once flourishing crop disappeared from Hawaiian agriculture almost wholly—but not quite completely, for a few determined farmers went to the trouble of keeping a paper covering over each individual melon from its infancy until ready to pluck, as a means of protecting it from the melon fly, and in this way were able to offer a few in the market at very high prices. The technique of this practice has improved in the past few years and meanwhile the melon fly has diminished greatly in its abundance so that the culture of watermelons and cantaloupes is returning to a place of some economic importance, and locally produced melons are being offered in our markets at much lower prices than prevailed a decade or two ago.

A recent census of crops shows over 800 acres planted to watermelons in 1936, with a small additional acreage (about 50 acres) producing cantaloupes. With further inroads on the melon fly pest being made by the intro-

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<sup>10</sup>Trans. Royal Haw'n Agr. Soc. Vol. I, No. 2, p. 87, 1851.

duction of additional parasites, melon production may expand still further and become one of the more important of our minor industries.

Other kinds of melons cultivated in Hawaii include the following:

*Chinese Preserving Melon (Benincasa cerifera)*—a very large melon, 30 to 40 pounds, used very commonly as a cooked vegetable by the Chinese and others. In the mature stage it is diced and cooked with meats and other dishes, while in the immature stage it is used as a squash, or sometimes boiled whole and stuffed. As a confection this melon is excellent when cut in strips and heavily impregnated with sugar.

Ref.—U. H. Agr. Ext. Bul. 16:79-86, 1932; Trans. Royal Haw'n Agr. Soc. Vol. I, No. 1, p. 46, 1850; No. 2, p. 87, 1851; Haw. Exp. Sta. Annual Report, 1928:17; Bul. 60:35 (1929); 77:86-87 (recipes, uses, etc.).

**MEXICAN GRASS** Mexican grass (*Ixophorus unisetus*) is a comparatively recent introduction (1922) and is valuable chiefly for soiling purposes, as it will not withstand ordinary grazing.

Ref.—Haw. Exp. Sta. Bul. 65:25, 1933.

**MILLET** Millet (*Chaetochloa italica*), valuable in some cooler regions as a livestock feed, has been given a trial here, with indications that it is not as good as sudan grass under Hawaiian conditions.

Ref.—U. of H. Agr. Dept. Annual Report 1927:33.

**MINT** Mint (*Mentha spicata*) is found in limited quantities in many truck gardens and in some home gardens, as well. In total acreage, however, this plant could scarcely be considered as being of much economic importance. Its leaves are fragrant and used in the compounding of beverages and sometimes for garnishing meat dishes.

**MOLASSES** Cane molasses is a by-product of the sugar industry, about 450 pounds resulting from the manufacture of each ton of raw sugar, under Hawaiian conditions. Since Hawaii produces about a million tons of raw sugar per year, the total output of molasses is about 225,000 tons.

This important and abundant by-product is used in

several ways, and investigations are under way to still further extend its usefulness. Much of it is burned as fuel in the mills by spraying it upon bagasse as the latter is fed into the furnaces; the resulting ash makes good potash fertilizer. Some is applied directly to the soil as fertilizer for its beneficial effects in increasing the activity of soil bacteria. Some is made into alcohol for fuel or other industrial purposes, with yeast as a by-product. Some is fed to plantation animals, for the feed value of molasses has been recognized for a very long time.

A large part of the annual output of molasses is shipped out to be used as a component of mixed feeds manufactured on the mainland. This seems to be uneconomical<sup>11</sup> from the viewpoint of the Territory, for it is sold at only a few dollars a ton and comes back in mixed feeds for livestock at five or six times that figure. Since Hawaii is importing large quantities of these feeds for its dairy cattle, poultry and other livestock, it would seem logical to utilize more of our molasses here and thus perhaps reduce a little the cost of producing our milk, eggs, pork, etc. The F. L. Waldron Company, in Honolulu, is now beginning to enter this field. A feed mixing plant has been erected capable of turning out 40 tons in an eight-hour day. Molasses is a component part of most of the feeds manufactured in this plant, constituting perhaps on an average about 15 per cent of the various mixtures.

As a result of seven years of continuous experimentation upon the University dairy herd the Hawaii Experiment Station declares that cane molasses may safely be substituted for 25 per cent of the concentrates normally fed to dairy cows, if properly supplemented with high protein feeds. This would effect a material saving in the cost of milk production, the amount depending on prevailing costs of other feeds and of molasses.

It is declared, further, that the use of cane molasses in the manner suggested does not cause any significant reduction in reproductive efficiency of dairy cows, nor any increase in abortions.

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<sup>11</sup>For an excellent discussion of the economics of this, and a report on the utilization of molasses as a by-product, see *Planters Record* Vol. IX, 621-626 (1913); also other references cited in the general Index of 1915 (pp. 170-172) and in later volumes.

As a feed for hogs it has been shown by long continued tests at the University Farm that cane molasses may profitably be fed to swine in amounts up to 20 per cent of the total ration. This causes an increase in the daily gains in weight, at an appreciably reduced cost per unit. Hogs eat the molasses mixture readily and no bad physiological effects have been observed.

In the poultry yard, also, cane molasses is valuable as a feed, but to a more limited degree. In mixing the mash for chicks and young pullets and cockerels, molasses may be used in amounts not exceeding 7 per cent of the mash, according to tests at the University Farm. For laying hens it is not advisable to use molasses, but for fattening broilers it is good even in amounts as high as 15 per cent of the total ration.

Ref.—Haw. Exp. Sta. Bulletins: No. 67—"Cane Molasses in Poultry Rations," 1933; No. 69—"Cane Molasses as a Supplement to Fattening Rations for Swine," 1933; No. 73—"Cane Molasses as a Feed for Dairy Cows," 1934. Also, U. H. Agr. Dept. Annual Reports 1925:17; 1926:12; 1927:8, 17; 1929:32-35; U. H. Agr. Ext. Service, Agric. Notes No. 119, Nov. 29, 1935 (as feed for dairy cows). Planters Record XVI, 438; XX, 23.

**MOLASSES GRASS** Molasses grass (*Melinis minutiflora*) spreads by runners and forms a mat. After cattle acquire a taste for it they relish it and fatten well on it. It is widely disseminated.

Ref.—Haw. Exp. Sta. Bul. 65:27, 1933; Annual Report 1936:19; Haw. For. Agr. 1930:61-64.

**MONSTERA** The monstera (*Monstera deliciosa*) is a clinging vine with very large leaves, frequently seen growing on the trunks of large trees. It is a relative of the taro plant and produces flowers of similar odd structure. The fruit is a long spike with many berries adhering to it, these being succulent and edible, suggestive of both the pineapple and banana in flavor. There is no commercial exploitation of this fruit in Hawaii.

Ref.—Bryan, Natural History of Hawaii (1915), p. 249; Haw. For. Agr. 1909:275.

**MOUNTAIN APPLE** The mountain apple or Ohia ai (*Eugenia malaccensis*) grows wild in moist, shady portions of the coastal river valleys of all the Islands, to an elevation of about 1,800 feet. The fruits are of a

beautiful reddish color on the outside and white within, and are borne on very short stems attached to the trunk and main branches. Although much relished by mountain hikers for its cool, refreshing effects, this fruit is not considered to have any great commercial value; it is sold in season by numerous roadside vendors, and occasionally is offered in the city markets.

Ref.—Wilder, "Fruits of Hawaii" (1906), p. 20; Haw. Exp. Sta. Bul. 77:55 (uses).

**MUGWORT** Mugwort (*Artemisia vulgaris*) is a perennial shrub which grows readily in the drier portions of these Islands. Its grayish green leaves are fragrant with an odor suggestive of sage and are used by the Japanese in flavoring and coloring festival rice cakes. Production is very limited, as is the market demand, also.

Ref.—Haw. Exp. Sta. Bul. 60, p. 19, 1929.

**MULBERRY** Although the mulberry tree (*Morus nigra*) produces a fruit which is sometimes used in making jam and preserves, it is far better known for its association with the silk industry. For many centuries silk worms have been raised on mulberry leaves as their sole food, and in silk producing countries the culture of the mulberry has long been an important art.

Silk culture was first tried in Hawaii in 1836 (see "Silk") and the mulberry was introduced at the same time to serve as feed for the worms. Although its cultivation increased rapidly for a few years, it soon dwindled with the realization that the infant silk industry was not destined to become large. Today the mulberry occurs only here and there in single plantings or small clusters. It is of no commercial significance.

If there should be a renewal of effort to establish a silk industry here, the mulberry tree would probably come into some importance, unless perhaps another food plant should be discovered to be superior for silk worms. Lettuce has been used successfully in some countries for this purpose.

**MULES**<sup>12</sup> Mules have been used extensively in agricultural work in Hawaii and many are produced on the

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<sup>12</sup>This statement was prepared by Prof. L. A. Henke.

bigger ranches, notably the Parker Ranch. A large number have also been imported and some are still being imported but to a much lesser degree at the present time. Tractors have replaced mule power to quite an extent but the decline in the mule population has been less marked than that of horses, as is shown in the following U. S. Census figures:—

*HORSES AND MULES IN HAWAII*

	1900	1910	1920	1930
Horses .....	12,982	15,856	24,307	15,797
Mules .....	6,506	7,956	10,542	8,998

Importation of horses and mules to Hawaii has declined greatly in recent years as shown below:

*IMPORTATION OF HORSES AND MULES TO HAWAII*

<i>Inclusive years</i>	<i>Horses</i>	<i>Mules</i>
1921-25 .....	366	1,747
1926-30 .....	497	1,221
1931-35 .....	147	124

**MUNGO BEAN** See "Bean."

**MUSHROOMS** Mushroom culture has been tried in Hawaii on a small scale by several people, but never with enough success to encourage continuation or expansion. Information on cultural practices is available but seldom used.

See also "Pepeiao akua."

Ref.—Haw. For. Agr. 1915:243-245.

**MUSKMELON** See "Melons."

**MUSTARD** A species of mustard (*Sinapis chinensis*) is used by the Japanese as a potherb or greens, always in the seedling stage when the plant is small and tender. The leaves have a pleasant flavor and should have a much wider market demand than now is the case. Production is very limited.

See also "Leaf Mustard."

Ref.—Haw. Exp. Sta. Bul. 60, p. 21, 1929.

**NAPIER GRASS** See "Elephant Grass."

**NASEBERRY** See "Sapodilla."

**NATAL PLUM** See "Carissa."

**NUT GRASS CONTROL** Nut grass (*Cyperus*

*rotundus*) is a small sedge which may grow sufficiently abundantly in moist soils to constitute a serious handicap to cultivated crops. It spreads by small tubers on underground stems and from seeds, also. Its normal habit of growth is to a height of three to nine inches, with the numerous upright stalks crowded together into a dense mat.

The growth above ground may easily be killed by an application of arsenite of soda spray, or other weed poisons, but within a few weeks the underground tubers have sent up a new jungle of growth, apparently none the worse for the poison attack. Repeated applications of poison, before the nut grass flowers and seeds, will eventually wear out the vitality of the tubers and after several years control can thus be effected, but at great expense.

Frequent discing and stirring reduces this grass pest materially but does not eradicate it. Tubers brought to the surface and exposed long enough to the drying effects of sun and wind lose their power of growth.

Small patches of soil can be freed from nut grass by steaming or by application of chloropicrin.

Covering infested areas with mulching paper sometimes is an effective control measure.

Ref.—Haw. Exp. Sta. Annual Reports 1915:43; 1916:31; 1917:50; U. of H. Research Publ. No. 6, p. 67, 1932.

**NUTMEG** A few nutmeg trees (*Myristica fragrans*) are to be found in gardens in Hawaii. This source of commercial spice was never developed into an industry here, although it has been urged more than once.

Ref.—Planters Monthly XI, 69-72 (1892); XVII, 85-88, 308-309 (1898); Haw. For. Agr. 1906:305.

**NUTS** Plants producing commercially valuable nuts known in Hawaii and discussed in this review are the following:

- Betel nut
- Cacao
- Cashew nut
- Coconut
- Jesuit nut
- Kamani
- Kukui



Macadamia  
Malabar chestnut  
Peanut  
Vegetable Ivory  
Walnut  
Water-chestnut

**OATGRASS** See "Tall Oatgrass."

**OHELO** The ohelo berry (*Vaccinium reticulatum*), related to the common cranberry, is a native of Hawaii and was one of the few kinds of fruits which were available to the ancient Hawaiians. It grows most abundantly in the vicinity of Kilauea Volcano, and does not thrive well at the lower elevations.

Ohelo berries are used in the making of jams, jellies and pastries, for which there is a limited demand commercially. It is possible that this might be extended enough to justify a larger production under cultivation, but there are other fruits which are more promising for commercial exploitation.

**OHIA** A conspicuous feature of all Hawaiian forests is the ohia tree (*Metrosideros collina polymorpha*) which is used for fence posts by ranchmen and as a source of lumber. The wood is hard and beautifully grained and therefore useful for flooring and similar purposes. For information concerning this, refer to Hawaiian Forester and Agriculturist, Vol. VII (1910), pp. 118-126.

See also "Forest Products," and "Tan-bark."

**OHIA AI** See "Mountain Apple."

**OKOLEHAO** See "Alcohol," also "Ti."

**OKRA** Okra (*Hibiscus esculentus*) is a sub-tropical plant and thrives well in Hawaii. Its seed pods are somewhat fleshy and when immature are used sometimes in soup. As the demand is very limited, production is on a very small scale, the aggregate of many small plantings probably being less than 5 acres.

**OLIVE** The olive (*Olea europaea*) is a temperate zone fruit tree which was introduced into Hawaii during the nineteenth century but has not found it as congenial a situation as in Italy or Spain or Southern Cali-

fornia. A commercial planting of several acres was made in Kalihi Valley (Honolulu) in the 1880's but abandoned after several years when the trees failed to bear well. There are some trees growing in Honolulu as ornamentals but they seldom develop fruits.

In the cooler uplands, especially where it is not very rainy, the results are better. In 1895 some olive trees were planted at Puuwaawaa, Island of Hawaii, at an elevation of 3,500 feet by E. P. Low. Although given no special care, they began fruiting in 5 years and produced good crops of excellent fruit.

Although this would indicate some possibilities for an olive industry in high and semi-arid localities, no serious efforts have been made to develop it.

Ref.—Haw. For. Agr. 1904:285-6. Planters. Monthly VII, 315 (1888); X, 37 (1891).

**OLONA** Olona (*Touchardia latifolia*) is a native plant of Hawaii and the source of an unusually tough and strong fiber which has long been used by the Hawaiians for fish nets, canoe lashings, house framing and other purposes. Unfortunately, the ease with which one can obtain certain fibers introduced by western civilization has pushed this superior kind into the discard and it is seldom seen or used now.

The olona plant is said to be easy to propagate by certain recognized techniques. The source of the fiber is a thin intermediate layer in the bark, both an outer and an inner layer having to be stripped off to expose the part desired.

A committee of the Royal Hawaiian Agricultural Society<sup>1</sup> reported in 1854 that, "if the olona is well cleaned, and could it be separated into its distinct fibers by machinery, and then manufactured into strands, and these strands laid into rope. it would exceed in strength any foreign cordage ever brought here."

During the reign of King Kalakaua olona fiber was exported to Switzerland where it was useful in mountain climbing because of its great strength and imperviousness to moisture.<sup>2</sup>

An excellent account of the early production methods

<sup>1</sup>Transactions, Vol. II, No. 1, pp. 142-144 (1854).

<sup>2</sup>Honolulu Advertiser (editorial) Dec. 15, 1935.

and uses of this native fiber is contained in an article by S. M. Kamakau in Thrum's Annual 1919, pp. 69-74.

**ONION** The onion (*Allium cepa*), with its relatives, garlic and leek, is produced only to a limited extent in Hawaii, although the demand is relatively large and very steady. Krauss, in his bulletin<sup>3</sup> on vegetable production in Hawaii urges an expansion of local production, stating that "next to potatoes, cured onions are the vegetable crop most extensively imported into Hawaii. The 1930 imports amounted to 4,731,187 pounds valued at \$177,419. There seems to be no good reason why the truck farmers of Hawaii should not grow most of the onions consumed in Hawaii, and, possibly, export some stocks to the mainland during off seasons there. A decade or two ago, very choice Bermuda onions were grown on windward Oahu, on Maui, and in several other districts of the Territory, but heavy importations from Australia finally caused this infant industry to languish and die.

"Onion growing is an intensive culture and only the skilled truck farmer, favorably located in respect to soil and climate, should attempt to grow onions extensively. No attempt should be made to produce onions in excessively rainy districts, because of the weed factor and the difficulty of ripening the bulbs."

A recent crop survey (1936) indicates that local production of bulb onions occupies about 115 acres, with an additional 30 acres devoted to green onions and leeks. The Bermuda is practically the only variety of bulb onion produced here, and its cultivation is mostly in the sandy loam areas on windward Oahu.

Green onions are in steady demand throughout the year. Perhaps the chief consumers are the Oriental people here, but the demand is by no means wholly from that source. Practically all commercial truck gardens near Honolulu and other centers of population in Hawaii devote some area to the production of green onions, and many homes do likewise.

For detailed information on planting, cultivation, harvesting and marketing this crop, whether for bulb pro-

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<sup>3</sup>Agr. Ext. Bul. 16, pp. 105-113, 1932.

duction or greens, consult the Krauss bulletin referred to above.

**ORANGE** The common orange (*Citrus aurantium*) was brought to Hawaii in 1792 by Vancouver. He stopped at Tahiti before arriving in Hawaii and brought away from there some young trees and quantities of seed of a sweet and delicious orange which was prevalent there. This became well established and was known as the Polynesian orange. Some years later Mr. Greenwell introduced a variety from Monserrat, British West Indies, which became known as the Kona orange. Although scores of varieties have been brought in subsequently from many countries, this latter still seems to be the best, for local conditions.

In the early part of the nineteenth century Vancouver's orange became well established and rather widely planted, but not in orchards so much as in back-yard clusters of trees.

Exports of this and the Kona variety to California began about 1840 and for about 30 years there was a fairly brisk business in marketing oranges in the Golden State. According to early records<sup>4</sup> this export business reached a yearly total of about 143,000 oranges in 1854.

With the passage of the gold rush years in California that state turned to agriculture, and in the southern portion there developed a citrus fruit industry which not only supplied that and neighboring states, but shipped its fruit out over the entire United States. By the end of the century the tables were turned and Hawaii was importing oranges from California.

In 1905 the Hawaii Experiment Station began asking why these Islands should not produce their own oranges. In the preceding year imports of citrus fruits had amounted to \$60,000, and it seemed that farmers here might just as well have that business.

Accordingly, Horticulturist J. E. Higgins gathered as many kinds of citrus fruit varieties as he could readily assemble and planted a small experimental orchard. Also, he compiled a bulletin by drawing upon various sources of information and this was sent out to awaken popular

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<sup>4</sup>Trans. Royal Haw'n Agr. Soc. 1851, p. 87.

interest in this one-time flourishing industry. That little experimental orchard is still growing at the foot of Punch-bowl, with a score or two of different varieties of oranges, mandarins, lemons, limes, grapefruit, etc. It has been a good source of bud wood for the propagation of thousands of young trees which are scattered all over the Territory.

It was found, however, that many kinds of insect and fungus enemies were lying in wait for the citrus fruit grower and if he did not wage expensive warfare against them they took most of his crop. It was much easier to buy California oranges and lemons.

Then in 1910 the dread Mediterranean fruitfly was discovered here, probably having been accidentally brought in from Australia a few years before that. California put a strict quarantine against shipping not only oranges but most other fruits from Hawaii into her ports, and in 1913 a federal quarantine was enacted, effective in all American ports.

This quarantine, in itself, need not have seriously affected the Hawaiian citrus fruit industry which was just then struggling feebly to be reborn, for no one really expected that our farmers would do any more than supply local needs, and the quarantine would not affect local trade. But the fruitfly became exceedingly abundant and created a strong reaction against the local oranges, for the pest had the very bad habit of propagating its maggots inside ripening oranges and other fruits and the average consumer did not like to find the fruits thus occupied. Consequently, he preferred California oranges, even if they did cost a little more, and what little business had seemed to be starting here quickly languished.

The introduction of parasites gradually brought the fruitfly under partial control and hopes began to revive for a small orange industry. This was especially true in the Kona district of Hawaii, for it happened that coffee berries were a favorite host fruit of the fruitfly and the parasites were able to reach nearly all the maggots in coffee, while at least half of those in oranges and other large fruits escaped. In the coffee region, therefore, the effectiveness of the parasites was much greater than elsewhere, and orange growers there found their fruit only

rarely infested in the late 1920's, whereas a decade earlier few fruits had escaped the ravages of the fruitfly.

The Experiment Station then renewed its efforts, though on a comparatively small scale, to push orange culture into something of an industry. Many hundreds of young budded trees of approved varieties were distributed free, for trial, and a second bulletin was published (in 1934) to tell the public how to care for these trees, and what varieties to select. The old Kona variety was said to be the best among the oranges; the California navel orange does not seem to do well here.

In 1931 a new attack against the fruitfly was begun here by the U. S. Department of Agriculture. Following its successful battle in eradicating the same pest in Florida, the federal department transferred its activities here and is now engaged in discovering means of treating fruit which may harbor the pest so that it can be shipped to American markets without endangering fruit industries on the mainland. While it is not likely that any considerable exportation of oranges will result from this work, it is possible that some other kinds of citrus fruit might be produced for export, as limes or some other that is less susceptible to injury by the fruitfly.

Hawaii does not have ideal conditions for the production of oranges on a commercial scale. The climate is a little more tropical than it ought to be for the ideal situation, and the general conditions of climate and terrain are too favorable to insect pests. Without a winter season to check them the insects keep on multiplying throughout the entire year and become enormously abundant, and the mountainous nature of most of our fruit producing lands makes it extremely difficult and expensive to apply the necessary insecticides. We fall, therefore, into the easier way of relying on parasites to control the pests, but they seldom do as thorough a job as we really need for commercial success.

Then, too, oranges in our tropical conditions do not take on the uniformity of color that the California oranges do, and this makes them seem less desirable to most consumers who judge a fruit first by its appearance. In flavor, our Hawaiian (Kona) oranges are sweeter than California oranges but they lack the acid tartness which

people like and so are usually rated as inferior to the imported product in flavor. This would militate against the development of any large commercial industry in citrus fruits.

It is possible, however, that it would be well worth while to increase the plantings of orange trees in back yards and home gardens. They grow so easily that any householder with sufficient space could have a few trees for supplying home needs. Even if the fruits so produced were not of the best appearance, they would taste better because they grew at home. Likewise, a lime tree would supply home needs for lemons for a large part of each year, and a mandarin or Kona orange tree or two would save the expense of buying at the market.

See also "Chinese Orange," "Mandarin Orange" and "Citrus Fruits."

Ref.—Haw. Exp. Sta. Bul. 9 (1905); Bul. 71, "Citrus Culture in Hawaii," (1934); Bul. 77:56-58 (uses); Annual Rep. 1905:61; 1906:33; 1909:47; 1910:35; 1911:38; 1912:43; 1915:66; 1921:16; 1922:3; 1923:5; 1924:6; 1926:4; 1927:8; 1930:29; 1933:9; Thrum's Annual 1892:75; 1921:90-96 (W. T. Pope, on restoration of industry).

**ORCHARD GRASS** Orchard grass (*Dactylis glomerata*) is suitable only for the higher elevations, above 4,000 feet, where it is valuable for pasturage.

Ref.—Haw. Exp. Sta. Bul. 65:16, 1933.

**OSTRICH** Ostrich farming offered attractive possibilities in the latter part of the nineteenth century, when the demand for plumes was at its height. A small farm was established near Honolulu by Charles M. Cooke in the 1890's, with some 15 or 20 birds. Later, the activities were transferred to Kauai, but the project was not continued long.<sup>5</sup>

More recently, within the last few years, Paul Fagan undertook to establish ostrich farming on Molokai, but no results of commercial importance followed.

**OYSTER PLANT** See "Salsify."

**PANICUM GRASS** Panicum grass (*Panicum purpurascens*<sup>1</sup>), called also para grass, was introduced in

<sup>5</sup>Information furnished by Mr. Richard A. Cooke.

<sup>1</sup>Sometimes referred to as *Panicum barbinode*.

1902 and is now widely disseminated. It is valuable for pasturage and for fattening paddocks, and is often cut for use as green fodder for dairies. It is used as a soiling crop in pineapple fields.

Ref.—Haw. Exp. Sta. Bul. 65:31, 1933. Also, U.H. Agr. Dept. Annual Report 1922:18.

**PAPAIN** Papain is a digestive enzyme present in the milky exudation from the green fruits and the leaves and stem of the papaya. Although in Hawaii there has been no commercial exploitation of this, in some countries it is an important by-product. Considerable quantities of the dried exudation (known to the trade as “paw-paw juice”) containing the enzyme are imported into the United States annually<sup>2</sup> to be used in the manufacture of certain patented preparations used as aids to digestion. A chemical study of papain is in progress in the University laboratories by Prof. F. T. Dillingham.

See also “Bromelin.”

**PAPAYA** This delicious fruit (*Carica papaya*) has been known and used for several centuries in the American tropics and is believed to have originated in Mexico by a natural hybridization, or perhaps as a sport. In the seventeenth century it was carried to India and thence spread throughout the tropical regions of the Old World. Sometime before the discovery trip of Captain Cook it seems to have been introduced into Hawaii,<sup>3</sup> if we may credit certain circumstantial evidence. The papaya is not mentioned in the list of agricultural products noted by Captain Cook’s crew, but on the other hand, subsequent observers reported that the Hawaiians appeared to be familiar with the fruit, thus suggesting that it had been known to them a long time.

The papaya is not closely related to any other familiar fruit; the papaw of North America is not even a distant relative.

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<sup>2</sup> 1931 .....	65,257 pounds valued at \$121,481
1932 .....	54,491 pounds valued at 50,565
1933 .....	83,334 pounds valued at 79,007
1934 .....	111,209 pounds valued at 189,057

<sup>3</sup>See Pope, Bul. 61, Hawaii Exp. Sta., p. 2, 1930.



In its flowering and fruiting habits it is erratic and unstable. Most of the cultivated varieties usually produce stamens and pistils in separate flowers on separate plants, but occasionally it happens that a staminate flower has a fully developed pistil and sets a fruit on a tree which is supposed to be "male." These are not "male" fruits, however, for their seeds seem to produce about the usual percentage of staminate and pistillate trees.

These two sex forms are not distinguishable until the flowers begin to form, then the "males" produce long, pendent clusters of flowers and the "females" (pistillate) develop larger flowers singly, each with a very short stem and many crowded closely together at the base of the leaf stalks. "Male" fruits, therefore, can be distinguished readily from normal fruit by the habit of hanging from a long stem.

Many claims have been made for various methods for distinguishing between males and females in the seed or seedling stage, but none have stood the test of scientific experimentation.<sup>4</sup>

Propagation of the papaya is usually effected by the planting of fresh seeds; it is possible, with difficulty, to root cuttings in a sand box but the resulting plants are not as vigorous as seedlings. Grafting has been successfully done but not commonly and thus far it offers no attractive promise as a means of propagation.

Successful propagating by seeds requires that the seeds be of as near a pure strain as possible, and this may be guaranteed by first isolating a good strain through plant breeding methods and then growing no other strain within cross-pollination distance of it.

The growth of the papaya plant is rapid, usually maturing its first fruits in about a year from the planting of the seedlings. It bears actively and continuously for three to five years, then goes into a decline. For detailed information about culture and selection of varieties, consult Dr. Pope's bulletin already cited.

The nutritional value of the papaya as human food was not fully appreciated in Hawaii until comparatively recently, the prevalent notion having been that it was a

<sup>4</sup>Pope, Bul. 61, Haw. Exp. Sta., p. 18, 1930.

fruit fit only for hogs. At about the beginning of this century, however, there began to develop an interest in this fruit in the mainland states, which caused the Hawaii Experiment Station in 1907 to begin some studies of the possibilities of shipping to the Pacific Coast. These tests were only partially completed when the fruitfly quarantine put an end to all dreams of an export industry, for the papaya was put on the list of prohibited fruits, even though it is but rarely infested.

This interest abroad, however, had the natural reaction of causing the people here to add the papaya to the diet and local consumption of this fruit has increased greatly, making its cultivation an industry of no mean size. The total plantings in 1936 were about 400 acres, with the market not fully supplied.

Prospects for the future are very encouraging. Efforts now being put forth to control the fruitfly or at least to devise some means of treating fruit so that the existing quarantine order may safely be modified to allow papaya shipments to the mainland seem to offer some promise of being successful. This would open the way to a very large market, for the papaya has been well advertised of late as a nutritious and health-giving fruit, for its papain content and its delicious flavor.

Meanwhile the Hawaii Experiment Station is investigating the possibilities of manufacturing various by-products from the papaya: preserves, juice, gelatine, and others. In addition, there is the possibility of extracting papain from the leaves and bark, and fiber from the trunk, thus increasing the profitableness of this crop.

Ref.—Haw. Exp. Sta. Bul. 61, "Papaya Culture In Hawaii," 1930; Bul. 77:59-65 (nutritive value and uses as food, etc.); Annual Reports 1902:320; 1910:33; 1911:26; 1912:40; 1913:22; 1914:29; 1915:24; 1919:28; 1920:20, 36; 1921:14; 1922:3; 1923:5; 1924:6; 1926:6; 1927:7, 1928:11; 1936:9, 26, 58 (nutrition studies). Thrum's Annual 1906:146-154 (article by H. M. Wells). Haw. For. Agr. 1904:136-138 (papain); 1905:278 (fiber extracted from trunk in Mexico, for paper making); 1913:100 (medicinal values).

**PARA GRASS** See "Panicum."

**PARSLEY** Parsley (*Petroselinum hortense*) is the most widely used garnishing plant on meat and fish dishes,

probably because of the delicate beauty and equally delicate flavor of its leaves. Although widely used, the total amount required is never large because of the fact that only a few sprigs are required at a family meal. It grows readily and well in Hawaii and is found in many commercial and home gardens, the total acreage being less than 5 acres for the Territory.

See also "Truck Crops."

**PARSNIP** The parsnip (*Pastinaca sativa*) is a relative of the familiar carrot. Although it can be produced here with comparative ease, most of the local demand for this vegetable is supplied by imports from the mainland. Small amounts are produced in our truck gardens, the aggregate probably not amounting to more than an acre or two. Shipments from the mainland total about 80,000 pounds per year, thus indicating that the consumption of this commodity is not very great.

See also "Truck Crops."

**PASSIFLORA** See "Passion Fruit."

**PASSION FRUIT** There are several kinds of passion fruit in Hawaii, all placed by botanists in the genus *Passiflora* and each known commonly by one or several colloquial names, as lilikoi, waterlemon, etc.

The most widely distributed species in this Territory is lilikoi (*Passiflora edulis*), the purple fruits of which are found at certain seasons of the year in the foothill regions of all our Islands. It was brought here from Australia about 1880 and from some of the early cultivated plantings it has been widely disseminated into the lower forest areas by birds.

Another species, commonly offered in local markets under the name "waterlemon" (*Passiflora lingularis*) is grown in semi-cultivation in Kona. This, also, is believed to have been brought here from Australia, probably about the same time as the other species, but there seems to be no certain knowledge about either of them as to the time and mode of arrival here.

Several other edible species are occasionally encountered here, including a yellow-fruited lilikoi which is thought to be a hybrid between the two species mentioned

above; also, a giant species, known as granadilla (*Passiflora quadrangularis*), which produces fruits as large as a small watermelon.

The edible portion of the passion fruit is the sweet, gelatinous matrix surrounding the seeds which are encased in a leathery shell. To eat a fruit out of hand, one cuts it open and swallows the gelatinous contents, seeds and all. The flavor is very agreeable, remotely suggestive of apricots.

It is not, however, in the fresh state but as the source of a bottled or canned juice that this fruit offers commercial possibilities which ought not to be overlooked in Hawaii, for the climatic conditions seem to be almost ideal for its cultivation here and heavy yields are being obtained in current tests at the Kona substation of the Hawaii Experiment Station. Grown on a trellis as an inter-crop between rows of more slowly growing trees the passiflora vines can be made to produce a quick revenue, provided (1) adequate facilities are available for processing the fruit and (2) adequate market outlets are opened by a campaign of advertising.

Our present knowledge concerning the cultivation of edible passion fruit is summarized well in Bulletin 74 of the Hawaii Experiment Station, published in 1935.

Ref.—Haw. Exp. Sta. Bul. 74, "The Edible Passion Fruit In Hawaii," 1935; Bul. 77:65-68 (uses, recipes, etc.); Annual Report 1936: 28, 94. "Passiflora edulis" by Jared G. Smith, in Hon. Advertiser, Nov. 29, 1935. See also, an article in The Fruit Products Journal, May, 1935, on improved methods of extracting juice of this fruit.

## PASTURE GRASSES See "Grasses."

**PEA** The common garden pea (*Pisum sativum*) is adapted to temperate zone conditions and is at some disadvantage in Hawaii. The production here is small, probably not over 10 acres in the entire Territory being devoted to this crop. Most of the local demand is filled by the imported canned product from the mainland. The quick freezing process now enables importers to bring in fresh peas (shelled) which by some people are preferred to the canned.

See also "Beans" and "Truck Crops."

Ref.—U. H. Agr. Ext. Bul. 16:60, 1932.

**PEACH** White foreigners settling in Hawaii longed for the temperate zone fruits to which they were accustomed: peaches, apples, plums, and others. They learned by repeated trials that most of them would not do well in the tropics except at high elevations where the climate was cooler. One variety of peach (*Prunus persica*), however, was found which grew well and produced fruit abundantly, even in the lowland areas of these Islands. It is believed to have been brought in from Asia, probably by early Chinese immigrants.

The fruit is small, the meat white, with a very delicious flavor. This variety of peach is frequently mentioned in horticultural notes and articles<sup>5</sup> and was much prized by all, especially the foreigners. The fruit sold for as much as fifty cents per pound at times.

Unfortunately, the accidental introduction of the Mediterranean fruitfly about 1910 put an end to any chance which may have existed of developing even a small peach growing industry here, for this fly found the peach a very delectable home for its maggoty offspring and it became very difficult to find any ripe fruits which were free from worms. So long, therefore, as this fruitfly pest continues to exist in Hawaii it will be practically impossible to consider the peach as a commercial possibility.

**PEANUT** Peanuts (*Arachis hypogea*) have been produced in Hawaii for a century, but never on a large scale.<sup>6</sup> The Chinese use peanut oil in the preparation of certain foods and naturally, therefore, they tried the growing of peanuts here as a means of obtaining the needed oil at a lower cost as compared with the imported product. There was not much saving, however, and importations continued to fill most of the local demand.

The Hawaii Experiment Station in 1902 called attention to the possibilities of extending this small industry to larger proportions, and in 1908 began some experiments to improve cultural methods. Several new varieties were introduced and some of them proved to be superior to the small type which the Chinese gardeners had been growing. A good bulletin on the peanut was

<sup>5</sup>As in Transactions of the Royal Hawaiian Agricultural Society, 1850-1856.

<sup>6</sup>A maximum of production last century was attained in 1872 when about 105,000 pounds of peanuts were exported.

issued at about that time,<sup>7</sup> giving directions as to the cultivation of this crop and the selection of proper locations for successful results.

It was pointed out that Hawaiian conditions are favorable for peanut production, since average yields of the better varieties were about one ton of cured nuts per acre. In the matter of quality of the nuts, it was said that both in flavor and firmness the Hawaiian product compared well with any other.

During the War years there was a further effort to develop an interest in peanut production on a larger scale, and some increase in the total acreage resulted; unfortunately, however, there was inadequate attention given to the selection of good seed and the harvested nuts were so variable in size and quality that they had little value for roasting and consequently found their way into oil manufacturing channels, but at prices too low to yield a profit to the producers.

There are certain areas in Hawaii where the soil and climate are very favorable for the peanut and where, with proper planting and cultivation methods, the crop could be made to pay at least a moderately good profit. At present very little of such land is used in this way, for current surveys indicate that the total plantings of peanuts in the Territory amount to less than 100 acres. The best varieties seem to be the White Spanish and the Improved Valencia.

Ref.—Haw. Exp. Sta. Annual Reports 1902:322; 1908:84; 1921:33; 1924:12; U.H. Agr. Dept. Annual Reports 1918:9; 1919:10; 1920:13; 1921:16; 1929:54. Planters Monthly XIII, 470 (1894).

**PEAR** The pear (*Pyrus communis*) is a temperate zone fruit grown in Hawaii only in the higher altitudes where climatic conditions are favorable. The total of several small plantings is less than five acres.

**PEPEIAO AKUA** Pepeiao akua<sup>8</sup> is the Hawaiian name for a fungus (*Hirneola polytricha*) which grows on the dead trunks and branches of the kukui tree (*Aleurites*) in the mountain forests. While this fungus is edible, it did not enter into use as a human food until the Chinese

<sup>7</sup>Haw. Agr. Exp. Sta. Press Bul. 28.

<sup>8</sup>The name translated literally means "ghost ears."

discovered that it was somewhat similar in taste to certain species of mushrooms to which they were accustomed in China.

During the gold rush years there were thousands of Chinese in California, and they found it exceedingly difficult for a time to secure their customary foods. When this Hawaiian fungus was offered to them as a substitute for mushrooms, they seized upon it eagerly and thus there developed a brisk trade almost over night. In 1851 some 5,000 pounds of the dried fungus was sold in San Francisco, most of it coming from the Waialua (Oahu) district.<sup>9</sup> It promised well as a business, for in the following year the shipments were trebled, to 15,000 pounds, with the price ranging from six cents to as high as forty cents per pound.

About 1855 the demand for this commodity in San Francisco diminished, but the local Chinese shippers found a ready market in China and forthwith shifted their activities. Steadier prices prevailed there, ranging from 9 to 12 cents per pound, and total annual shipments increased greatly after 1859; the maximum shipped to San Francisco had been 23,542 pounds (in 1853), but in 1860 the year's total to China jumped to 178,794 pounds and to 368,835 pounds in 1864. Thereafter the shipments declined irregularly to less than 100,000 pounds per year in the 1870's and less than 10,000 pounds annually in the 1880's, finally ceasing entirely in 1888.

The industry, at its height, had yielded a return to the Islands of about \$35,000 per year, but there was some fear that this was being more than offset by the destruction of kukui forests, for the fungus would grow only on dead trees and the exploiters of this commodity in their eagerness for larger supplies cut down many fine trees. The extinction of the industry was, therefore, not greatly regretted.

Ref.—Thrum's Annual 1914:201-203.

**PEPPERS** Two species of pepper (*Capsicum annuum* and *C. frutescens*) grow wild throughout the Territory, having been introduced a great many years ago, perhaps by Don Marin, who mentions in his diary that he "planted

<sup>9</sup>Trans. Royal Haw'n Agr. Soc. Vol. I, No. 4, p. 91.

peppers and chili" sometime about 1815, but gives no intimation as to the source of his material. It is quite likely that he obtained the seed from Mexico or South America. In more recent times several other species, mostly of the bell pepper type, have been introduced for commercial production. Although all do well here, none have entered extensively into cultivation. At present (1936) the total planting of bell peppers is less than twenty acres, and the acreage of chili peppers is practically negligible in amount. In the fresh state, bell peppers are barred from shipment to the mainland by the melon fly quarantine regulations.

The fact that large quantities of dried peppers are imported into the United States from foreign countries has been noted here on several occasions and used as an argument in favor of developing a large pepper industry in this Territory. Attention has been directed especially toward the two species which grow wild, for they fruit abundantly and prosper even with no cultivation. The Hawaii Experiment Station sought in 1903<sup>10</sup> to arouse popular interest in this potential industry, and at various intervals since then others have called attention to the commercial possibilities of this wild crop.

Recently, in response to inquiries from the mainland, the chemical laboratories of the University of Hawaii made some analyses of the local peppers.<sup>11</sup> Samples submitted at various times in the past to mainland dealers indicate that our product is of excellent quality and could find a good market, in competition with other producing areas. Interest in this prospect was beginning to gain some headway in 1931 and 1932 but was abruptly ended when the Territorial Board of Agriculture and Forestry ordered the destruction of all pepper plants as a means of eradicating a noxious insect. This order has subsequently been lifted and the way is again open to exploit this potential crop.

Ref.—U.H. Agr. Ext. Bul. 16:113-114, 1932; Haw. Exp. Sta. Annual Report 1903:404; U.H. Agr. Ext. Bul. 16:113, 1932.

**PERILLA** *Perilla frutescens* is a native of southern Asia and occasionally grown in Hawaii for its scented

<sup>10</sup>Annual Report 1903, p. 404.

<sup>11</sup>The investigational work was done by Dr. L. N. Bilger.



foliage which is used by Orientals in flavoring certain dishes. Its scent is suggestive of balsam, while in appearance the leaves resemble mint.

Ref.—Haw. Exp. Sta. Bul. 60, p. 20, 1929.

**PERSIMMON** The persimmon (*Diospyros kaki*) is a temperate zone fruit cultivated extensively in northern China and Japan. It was introduced into Hawaii a good many years ago but can be grown successfully only in the higher elevations where temperate zone conditions are simulated. On the uplands of Maui there are some small plantings aggregating perhaps 8 to 10 acres, and a few trees on other islands. Some fine specimens of fruits have been exhibited at county fairs, but the persimmon cannot be said to offer as attractive possibilities for Hawaii as many other fruits which are better adapted to this climate.

Ref.—Wilder, "Fruits of the Hawaiian Islands" (1911), pp. 170-171.

**PIA** See "Arrowroot," also "Cassava," and "Starch."

**PIGEON PEA** The Pigeon Pea (*Cajanus indicus*) has been cultivated as a food plant for many centuries in most of the tropical world and in some countries its dried beans are an important article in the diet of the people. By some it is believed to be one of the world's oldest cultivated plants.

Its first introduction into Hawaii seems to have been in 1824, by seed brought here by the captain of a whaling vessel.<sup>12</sup> Probably at other times, later, seed was brought from various parts of the world, for in the latter half of the nineteenth century it was recognized by botanists as being a well established plant in these Islands. However well it may have been established, it did not figure much as a cultivated crop, for its values to mankind were not appreciated here.

F. G. Krauss, whose name is inseparably linked with the pigeon pea because of his success in developing it into a very important crop, began his investigations of this plant in 1906. Although attached then to the Hawaii Experiment Station as a specialist in rice culture, he

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<sup>12</sup>James Macrae visited Hawaii in 1825 with Lord Byron and was shown a garden in Lahaina, Maui, containing flourishing pigeon pea plants from seeds brought in the year before. See Bul. 64, Haw. Exp. Sta., p. 12, 1932.

extended his studies to other crops which he thought might have some possibilities for commercial development. Among a number of leguminous plants tried in these investigations was the pigeon pea, from seed which had come to the Station from Porto Rico. A little later he added some other varieties of pigeon pea from India and other countries. Among many plantings he observed one small cluster of plants which grew much more luxuriantly and bore seed pods much more abundantly than the rest. This strain was preserved, propagated and built up by breeding and selection until it became the New Era variety which now covers thousands of acres of land in all parts of the Territory and has been sent to dozens of tropical and subtropical countries where it is displacing even varieties which are very ancient; so great may be the value of a single plant when recognized by an expert plantsman like Krauss.

At first the pigeon pea attracted interest here because of its obvious value as a windbreak. Its rapid and dense growth to a height of five to ten feet seemed to make it particularly useful in this way when protection was needed quickly for a vegetable garden.

Next came the realization that this plant had great value as a feed for livestock, providing about the same elements as alfalfa hay but at much lower cost, for alfalfa has always been difficult and expensive to grow here and equally expensive to import from California. Here was a new crop which would grow readily, seemed perfectly adapted to Hawaiian conditions and could be used either as pasturage or as hay. That realization established the pigeon pea firmly as an economic plant of great importance, and beef cattle producers began planting large experimental areas. The results were so good that by 1920 the plantings covered a thousand acres, and by 1930 eight thousand acres. The present acreage is approximately 6,000. For finishing off cattle for market a few months in pigeon pea pasturage is excellent, putting on good weight (one to two pounds per day) and marbling the beef almost as well as by finishing off on corn.

For other livestock, too, this plant is of very great value and is relished greatly. Hogs thrive on it, as do horses and mules, also sheep and goats. For poultry the

meal made by grinding pods and leaves is an excellent and nutritious feed.

Its value is not limited, however, to its use as feed for livestock. Being a leguminous plant, the pigeon pea develops nitrogen-containing root nodules and therefore is a good plant for green manuring. This caused pineapple growers to use it as a cover crop between cycles of planting, and thousands of acres were sown to the pigeon pea to be plowed under in a few months as a soil builder. For a time this practice was abandoned because of fear that the pigeon pea roots harbored large quantities of a tiny worm (nematode eel worm) injurious to pineapple plants, but later this seemed to be a groundless fear and the former popularity began to be regained, so that now there are large areas under this cover crop.

As bee pasturage the pigeon pea has some value, even though it is impossible to measure it in dollars and cents.

For bird reserves and hunting preserves the pigeon pea offers great possibilities, for the larger game birds such as pheasants and partridges thrive excellently on the dry seeds.

In most tropical countries it is as human food that the pigeon pea is especially valued, but in Hawaii this use has thus far been of very minor importance. This should not be, however, for the seed is very nutritious and has a flavor to which one could become accustomed quite as readily as to that of any other bean or pea. For large scale commercial production for its dried peas (really they are beans) this plant undoubtedly offers very great possibilities, whether the product be sold or canned.

Ref.—Haw. Exp. Sta. Bul. 64, 1932 (the most comprehensive and authoritative work on the subject); Annual Reports 1910:40; 1920:62; 1930:5; Thrum's Annual 1923:85-97 (F. G. Krauss).

**PIGEONS** The raising of pigeons and squabs for market is practiced in Hawaii only to a very limited extent. There is, however, a considerable demand from hotels and restaurants and the small industry could well be expanded sufficiently to meet local needs.

See "Poultry."

**PIKAKI** See "Floriculture."

**PILI GRASS** Pili grass (*Heteropogon contortus*) is

a lowland species well liked by cattle, and widely distributed. This should not be confused with the other pili grass growing at high elevations and not relished by livestock. This latter had formerly a definite economic value, for it provided most of the material for thatching the houses in earlier periods.

Ref.—Haw. Exp. Sta. Bul. 65:23, 1933.

**PILI NUT** The pili nut resembles the Brazil nut in flavor and general appearance, but is more rounded in shape and has a smooth shell. Two closely related species of this nut tree have been brought into Hawaii, *Canarium commune* from Java and *Canarium luzonicum* from the Philippines.

A large tree of the former may be seen at Nuuanu and Judd Streets, Honolulu, while smaller trees of both species occur in gardens as ornamentals.

No commercial exploitation of this nut has been attempted in this Territory, but it seems to offer some interesting possibilities.<sup>13</sup>

**PINEAPPLE** The pineapple (*Ananas comosus*), long recognized as the King of Fruits, is the basis of an industry in Hawaii second only to sugar production. The development of this industry, very remarkably, has occurred mostly during the present century and is the first major movement toward the diversification of Hawaii's agriculture. Many minor crops have contributed toward diversification but none has seemed able to claim and hold a position of near equality with sugar, as the canning of pineapple has done.

Although this industry is a twentieth century affair, the pineapple arrived in Hawaii probably a hundred years earlier. Its early history here is shrouded in some uncertainty. An entry in Don Marin's diary of November 14, 1809, declares that he had planted some pineapples.<sup>14</sup> Since many of his plants and seeds were brought from Mexico, it is probable that he obtained pineapple planting material there, for this fruit has been grown in tropical America for many centuries, its original home probably having been Brazil, whence it had been disseminated up

<sup>13</sup>Information furnished by Dr. H. L. Lyon, Director, H.S.P.A. Experiment Station.

<sup>14</sup>See Johnson's "The Pineapple," p. 5, 1935. (Paradise of the Pacific Press.)

and down through the American continents and into the West Indies. Columbus took some fruits back to Europe where they achieved great popularity in hot-house culture. Spanish and Portuguese mariners, probably in the sixteenth century or the seventeenth, carried the pineapple to the Philippines, East Indies and southern Asia, and it is possible that it reached Hawaii then, but not probable, for Captain Cook made no mention of the pineapple in his list of Hawaiian crops.

In the nineteenth century there developed something of an industry in the production of pineapples in the Kona district of the Big Island, the fruits being small and sweet, of the "Queen" type, probably the variety introduced by Marin. Shipments were made to Honolulu and other centers, where they were in demand not only for consumption by local residents but by the whaling crews, as well. A summary of exports in 1850-1851 includes an item of 21,000 pineapples.<sup>15</sup>

As this export business required double handling in the trip from Kona to Honolulu and then transfer to outbound ships, efforts were begun in 1885 to produce pineapples on Oahu. At first only the Hawaiian (Kona) variety was planted, but a little later several others were brought in from various parts of the world. Among these was the Smooth Cayenne, which subsequently became the basis of the great Hawaiian pineapple industry and displaced all other varieties from commercial planting.

"Mystery surrounds the origin of this, the finest of pineapples," writes J. L. Collins in his recent account of the evolution of the Hawaiian pineapple industry.<sup>16</sup> "There is even uncertainty regarding its first importation to Hawaii, for the Director of the Department of Agriculture of Jamaica, states that they sent Cayenne plants in the early '70's. However, no records of these plants in Hawaii have been found. In 1882, Captain John Kidwell arrived in Hawaii and soon became interested in growing pineapples. To him is given the credit of importing and demonstrating the value of the Cayenne

<sup>15</sup>Trans. Royal Haw'n Agr. Soc., Vol. I, No. 2, p. 87, 1851.

<sup>16</sup>Paradise of the Pacific Magazine (Honolulu) Dec. 1935, pp. 71-77.

variety.<sup>17</sup> He secured 12 plants from Florida in 1885 and 1,000 from Jamaica in 1886. Soon after this he collected 31 varieties from various parts of the world and tried them out on his farm in Manoa Valley which is now the site of the University of Hawaii.

"During the period of 1885 to 1893 there was an intensive interest in the growing of pineapples. During this period approximately 102,500 plants were imported (mostly Cayenne) from many parts of the world.

"Although Kidwell started his plantation for the purpose of supplying fresh fruit, he soon realized that the rapid expansion of the acreage would result in a supply much larger than could be absorbed by the limited fresh fruit market. In 1892 he, with the aid of John Emmeluth, began canning pineapples at a small cannery near Wai-pahu, Oahu. This company continued to preserve pine-apples until 1898 when the business was sold out to the Pearl City Fruit Company.

"These efforts of Kidwell undoubtedly furnished the foundation for the present pineapple canning industry. His pineapple canning was not the first to be done in Hawaii, however, for the year that Kidwell came to Honolulu, Akerman and Muller of North Kona, Hawaii, were preserving pineapples in tins which were reported to be 'of excellent flavor and would take first place in any market.' The variety which was canned by Akerman and Muller is not known but it was probably the Wild Kailua, the so-called Native Pine.

"The Cayenne, when introduced to Hawaii, was already an old and tried variety. Mention of it was made by English gardeners in one of their journals as early as 1842. The variety is probably 100 or more years old.

"This variety, when grown elsewhere, does not appear to produce fruits of such good quality as it does in Hawaii. It is indeed a remarkable variety because of its ability to produce so well in such a wide variety of climatic and soil conditions. It produces fruit from close to sea level to an elevation of 3,000 feet and in areas having an

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<sup>17</sup>W. H. Purvis secured several suckers of Smooth Cayenne from the Kew Gardens in England and planted them in Hawaii in 1885, which is claimed by some to have been the first introduction of this variety here. The first fruits were harvested in 1887 by D. McH. Forbes, Purvis' horticulturist. (Footnote by D. L. C., based on statement made to him by Forbes.)

annual rainfall from 20 to 100 inches. Temperature and soil conditions are also widely different. We have spoken primarily of Cayenne because it is the most widely grown variety in the Islands but it should be stated the industry makes use of two varieties, which are indeed very much alike. The Hilo variety is grown to a considerable extent on the island of Kauai, but very little is to be found on the other islands. Hilo differs from Cayenne in some fruit characters but most obviously in the almost complete absence of slips together with a large number of shoots. The canned fruit of these two varieties is so much alike that even cannery experts cannot with certainty distinguish them."

Annexation of Hawaii as a territory of the United States and the opening of a new homesteading tract in central Oahu in 1900 attracted a good many white farmers into the new pineapple industry, among them being James D. Dole, Alfred W. Eames and Byron O. Clark. Although some extensive efforts were put forth in the exportation of fresh pineapples, it was in the canned state that this fruit forged ahead in the American market. Production mounted rapidly from a few hundred cases in 1903 to over 12,000,000 cases (of 24 cans of about 2 pounds each) in 1930, making this industry one of the largest of canning activities anywhere in the world.

Growth<sup>18</sup> of the Pineapple Industry as Shown by the  
Increase in the Total Cases of Fruit Packed in  
Successive Years, 1903 to 1933<sup>19</sup>

<i>Year</i>	<i>Cases of Fruit Packed</i>	<i>Year</i>	<i>Cases of Fruit Packed</i>
1903.....	1,893	1919.....	5,071,976
1904.....	10,304	1920.....	5,986,982
1905.....	45,041	1921.....	5,262,503
1906.....	74,245	1922.....	4,770,239
1907.....	168,205	1923.....	5,895,747
1908.....	343,726	1924.....	6,825,904
1909.....	401,940	1925.....	8,728,580
1910.....	464,968	1926.....	8,939,590
1911.....	725,742	1927.....	8,879,252
1912.....	1,313,363	1928.....	8,663,056
1913.....	1,667,122	1929.....	9,211,376
1914.....	2,268,781	1930.....	12,672,296
1915.....	2,669,616	1931.....	12,726,291
1916.....	2,609,483	1932.....	5,063,793
1917.....	2,607,031	1933.....	7,813,540
1918.....	3,847,315		

<sup>18</sup>This table of figures is taken from the article by J. L. Collins referred to above.

<sup>19</sup>Since 1933 the industry has not published its annual packs, but it is known to be increasing very greatly over the relatively small totals of 1932 and 1933.

*Juice*—The canning of pineapple juice has in the past few years become a very important feature of the pineapple industry here, with the yearly pack running into millions of cases.<sup>20</sup>

Many years ago a strong effort was made to develop a market for pineapple juice, but without much success. At that time it was believed that only a clear juice, free from sediment, would be wanted by the public, and accordingly a clarified product was offered, in bottles. Unfortunately, the clarification process deprived the juice of its natural flavor and the results marketwise were very disappointing. Large quantities of the bottled juice remained unsold and after a few years the effort was abandoned to utilize in this way the juice that flowed so abundantly from the canning of the fruit.

Next came a scheme to concentrate the juice by partial evaporation into a thick, heavily sweetened liquor which was to be diluted for use in the making of fountain drinks. One such preparation was called "pinectar" and figured in the market in a minor degree for a few years. The concentrated juice did not prove popular, however, and its manufacture soon ceased.

For several years thereafter practically the only use made of the juice liberated in the canning of pineapples was to transform it into syrup, and in that way it became an item of considerable value to the industry. Some ten years ago, however, there began a revival of interest in the marketing of juice, but this time in as near its natural state as possible, with neither clarification nor concentration. Fresh, natural juice, with its suspended solids, was placed in cans and given a minimum of heat treatment for sterilization. It gained steadily in popularity until the point was reached where the juice flowing from the canning process as a by-product was insufficient to fill the demand and it became necessary to send many thousands of tons of pineapples through juice presses. Statistics are not available as to the total output of canned pineapple juice at present, but indications are that it is in excess of 4,000,000 cases per year and apparently destined to increase still more.

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<sup>20</sup>This output of canned juice is not included in the table of figures above.



*Research*—The early experimentation which led to the founding of this industry was by private individuals, as no research station was in existence here prior to the present century. With the establishment of the federal station in 1901 some attention began to be directed toward pineapple problems, at first mainly in the matter of insect pests but later (1909) some soil difficulties arose and were ably investigated by station experts.<sup>21</sup>

In 1914 the industry found it necessary to have more assistance than the Hawaii Experiment Station was able to give, especially in the problem of controlling pests and diseases, and turned to the Experiment Station of the Hawaiian Sugar Planters Association (H.S.P.A.). An arrangement was made for a certain amount of research work on pineapple problems to be done by various members of the sugar station. This plan continued in operation about ten years, the program of research work meanwhile having grown and expanded considerably.

In 1924 an experiment station was established by the pineapple industry, affiliated with the University of Hawaii but supported independently by an assessment on the pack of pineapples.<sup>22</sup> This has subsequently become a large and important research institution, with excellent laboratories at the University campus.

The industry has organized a cooperative association which "is composed of seven companies"<sup>23</sup> producing pineapples on Oahu, Molokai, Maui, Lanai and Kauai. The fruit is preserved in nine canneries of which three are in Honolulu, four on Maui, and two on Kauai. A few pineapples are grown by independent farmers and there is on Kauai an association of Japanese growers which operates a small cannery independent of the Cooperative Association.

"There are approximately 90,000 acres of land avail-

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<sup>21</sup>See Bulletins 26, 28 and 52 of the Hawaii Experiment Station.

<sup>22</sup>See R. N. Chapman "Cooperation in the Hawaiian Pineapple Business." Amer. Council, Institute Pacific Relations, p. 8 (1933).

<sup>23</sup>Quotation is from Collins' article cited above. The cooperative association referred to is the Pineapple Producers Cooperative Association formed in 1932 as a result of the depression; preceding this, there had been the Association of Hawaiian Pineapple Canners, which established the experiment station referred to above. For an account of the major achievements of this Station, see Collins' article cited above, pp. 76-77, also numerous publications of the Station itself.

able for pineapple growing in the island group. At no one time is the total acreage producing fruit. Each plantation is so organized that every year a portion of its land is in each of the following stages of pineapple culture:

1. Young plants not yet reached fruiting age.
2. Plants producing fruit.
3. Fields of old plants which have completed their period of productiveness.
4. Fallow fields. These may be without growing pineapple plants for one to three years. Part of this time fallow fields will produce cover crops intended to prevent soil erosion and to increase organic soil matter. This period, when no pineapples are grown, is called the intercycle."

In addition to the sales of millions of cases of the canned product, there is some business in the shipping of the fresh fruit to the mainland, the total of such shipments in a typical year amounting to a little less than 50,000 boxes<sup>24</sup> of about 75 pounds each. There is considerable loss suffered from decay in transit, for the Smooth Cayenne pineapple is not a good shipper. Returns from these exports add perhaps \$100,000 to the value of the entire industry, and in addition there is a large volume of local sales of the fresh fruit which is probably equal to the amount shipped away in the fresh state.

*By-products* of the pineapple canning industry are important commercially and add materially to the returns from this fruit. First, is a large amount of juice which is caught and conserved, most of it being boiled down and made into syrup to be used in the canning process. Much of it, however, is canned for sale as juice.

The second by-product is pineapple bran (which see) made from the shell and core. Third is alcohol distilled from the fermenting waste and juice. Fourth is calcium citrate and its derivative, citric acid, both in much demand commercially. Vinegar is another by-product, made in

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<sup>24</sup> 1931 .....	38,308 boxes
1932 .....	59,027 boxes
1933 .....	46,324 boxes
1934 .....	33,303 boxes
1935 .....	53,990 boxes

one cannery. For a detailed statement of by-products see Thrum's Annual 1932:77-82 (article by D. W. Malott), and 1926:87-91 (T. F. Sedgwick).

Among possible new by-products which might be developed is the extraction of fiber from the leaves. It is known that the fiber of the pineapple leaf is good for the making of a fine cloth, but it is not known whether the Smooth Cayenne variety would be suitable for this purpose.

There is an abundance of published information pertaining to the pineapple industry in Hawaii, including cultural practices, disease and pest problems, canning, marketing, etc. The following list is by no means exhaustive.

Ref.—“The Pineapple” by Maxwell O. Johnson, p. 306, *Paradise of the Pacific* Press 1935 (contains an excellent and extensive bibliog.) “Paradox in Hawaii” by D. L. Crawford, Chapter IV, pp. 85-105, Stratford Press, 1933. “Cooperation in the Hawaiian Pineapple Business” by R. N. Chapman (American Council, Institute of Pacific Relations, 1933); “Evolution of the Hawaiian Pineapple Industry” by J. L. Collins (*Paradise of Pacific Magazine*, pp. 71-77, Dec., 1935). Haw. Exp. Sta. Bul. 26—“Manganese in Plants and Soils,” 1912; Haw. Exp. Sta. Bul. 28—“Manganese in Pineapple Plants,” 1912; Haw. Exp. Sta. Bul. 52—“Manganese Chlorosis of Pineapples,” 1924; Haw. Exp. Sta. Bul. 77, pp. 69-72 (uses, recipes, etc.). Haw. Exp. Sta. Annual Reports: 1902:318, 1903:406; 1907:57; 1908:27; 1909:58; 1910:14, 41; 1912:35; 1913:23; 1914:33; 1915:58; 1916:14, 23, 36; 1917:11, 25; 1918:20, 44; 1919:37; 1920:20, 35, 43. Thrum's Annual 1909:58-82; 1917:36-46; 1935:87-89. Haw. For. Agr. 1904:334-335 (Kidwell).

**PINEAPPLE BRAN** Pineapple bran is the trade name applied to a by-product of Hawaiian pineapple canneries made by drying and grinding the rind and core. Preliminary experiments by H. E. Savage of the Hawaiian Pineapple Co., with the cooperation of Professor L. A. Henke of the University of Hawaii, led to the first commercial manufacturing of this product in 1923, when the total out-turn was 1,726 tons. In subsequent years it has increased to over 10,000 tons per year.

Pineapple bran has a considerable value as a feed for livestock, a fact established both experimentally and by practical use on a large scale. Chemical analysis shows that it is rich in sugar and starch and has some protein,

also; its fiber content adds some roughage value. It is essentially an energy-producing food and is, therefore, valuable for work animals. It is used extensively on plantations as a feed for horses and mules, in combination with barley and hay.

For dairy cattle it has been demonstrated to be a good feed when used in proper combination with other concentrates. The cattle relish the pineapple bran and the milk flow increases, resulting in an appreciable decrease in the cost of milk production without affecting the quality.

Hogs fed on a ration containing 50 per cent pineapple bran gain less rapidly but at less cost per pound of gain than with imported concentrates.

As a feed for poultry pineapple bran is of much less value than for other livestock. Egg production seems to decline when any considerable percentage is added to the feed mixtures.

Ref.—Haw. Exp. Sta. Circ. 2, "Pineapple Bran as a Feed for Livestock," 1931. Also, U.H. Agr. Dept. Annual Reports 1922:37-40; 1924:18, 28; 1925:24-32; 1926:14-21; 1927:7; 1928:11; 1929:7-11.

**PINEAPPLE GUAVA** See "Feijoa."

**PLUMERIA** See "Floriculture."

**POHA** The poha (*Physalis peruviana*), sometimes called ground cherry or Cape gooseberry, resembles a small tomato in some respects. It is an introduced plant and probably originally was cultivated but it has long since escaped into the wild state and now occurs in the lower foothills and waste areas, though not abundantly. The fruit grows inside a papery husk and hence escapes injury from the fruitflies.

The poha is very commonly used in the making of jams, jellies and preserves and is the basis of a small industry which might be considerably expanded. While there is some cultivation of this fruit, the total area is very small, most of the home canning depending on the wild product for its supplies.

It is quite possible that an industry of important size could be developed by cultivating large areas of this fruit in regions well suited to it, as the Kona and Glen-

wood regions of Hawaii, and establishing canning plants nearby, to keep transportation costs at a minimum.

Ref.—Haw. Exp. Sta. Annual Report 1921:23. Bul. 47, pp. 20-22, 1923; Bul. 77:73-76 (uses, recipes, etc.).

**POI** Poi is the staff of life of the Hawaiian people. It is a very nutritious food made by steaming taro corms until thoroughly cooked, then removing the outer peeling and mashing the rest into a pulp which is allowed to ferment for several days. Its characteristic flavor is such that one must acquire a taste for it before relishing it and for this reason there is little probability that this product would find a ready market outside of Hawaii of any considerable size, notwithstanding the fact that it is believed to have special value as a food for convalescents, invalids and infants.

For possibilities of transforming it into other foods with larger market possibilities, see "Taro."

For details of poi manufacture see Haw. Exp. Sta. Bul. 70, "The Manufacture of Poi From Taro in Hawaii," published in 1933.

**POMEGRANATE** The pomegranate (*Punica granatum*) is a familiar fruit, grown in many parts of the world and common in the gardens of Hawaii. Its fruits are about the size of an apple, its leathery skin enclosing a multitude of small compartments packed together like cells of honey-comb and each containing a sweet, juicy morsel.

There is no considerable market demand for this fruit, however delicious it may be, and most of it falls to the ground unused.

The bark of the tree and the skin of the fruit contain a liberal amount of tannin which in some countries is used for tanning fine Morocco leather.

Ref.—Wilder, "Fruits of the Hawaiian Islands" (1911), p. 12.

**POMELO** See "Grapefruit."

**PORTUGUESE PLUM** See "Java Plum."

**POTATO** The Irish potato (*Solanum tuberosum*) is a western innovation in Hawaii, probably the first planting having been by Marin prior to 1813, for his journal of that year says that "he had planted at sundry times"

a long list of things new to Hawaii, Irish potatoes among other items. Probably from this beginning or perhaps from some other introduction, it was occasionally planted by Hawaiians, but by no means commonly, for it was rarely seen in the markets before 1835 and the native people did not use it as a food.

Gradually they learned that it had value and increased their plantings, especially in the Kula uplands of Maui. By 1840 potato growing had become a recognized, though still small, industry and the farmers used to carry them in barrels on their backs to the ports where whaling ships would buy them, paying in cloth the equivalent of from \$1.00 to \$3.00 per barrel.

During the early years of the California gold rush there was a very great demand for Hawaiian potatoes and at almost unbelievable prices. One account<sup>25</sup> tells of a whaler who loaded his ship with as many barrels of potatoes as he could obtain at a dollar or two per barrel and sold them in California at forty to fifty dollars per barrel! This situation, of course, did not last long, for California began producing its own potatoes and other foodstuffs as soon as the worst of the gold fever had subsided. For a few years, however, the Irish potato topped the list of all exports from Hawaii, in the best year (1850) there having been 71,985 barrels sent out.<sup>26</sup> At the height of this movement, the eagerness to obtain potatoes for shipment became so intense that even half grown plants were dug up and the miniature tubers sold, for the prices offered here had gone up to \$8.00 or \$9.00 per barrel and too little attention was given to quality. This naturally brought disastrous results, for Hawaiian potatoes earned the reputation in California of being exceedingly poor and the market demand dropped off in consequence.

The situation changed swiftly: in 1848 to 1851 Hawaii was supplying California's needs, as just stated; by 1854 California was shipping potatoes to Hawaii. When boom prices receded to respectable levels, most producers here lost interest and ceased growing potatoes,

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<sup>25</sup>G. D. Gilman, in *Trans. Royal Haw'n Agr. Soc.*, Vol. II, No. 1, p. 139 (1854).

<sup>26</sup>*Trans. Royal Haw'n Agr. Soc.*, Vol. I, No. 2, p. 87.

so that even home consumption needs could not be met. Growers were urged to return at least to the extent of meeting local needs and filling the demand from the whaling fleets; this total need was estimated in 1854 to be about 20,000 barrels. But the response was not forthcoming. In a very few years the whaling industry itself began to wane, and the once-flourishing potato industry passed out almost completely, until 1932 when a new combination of world events pushed it out again into a new role.

Prior to this latter date interest in the potato had not lain dormant, for the Hawaii Experiment Station began in 1901 to call attention to it as a crop that had once been of great importance and should be again. Test plots were planted with many imported varieties in an effort to discover some that would be resistant to the diseases which seemed more virulent here in the tropics than in the temperate zone. Because of its importance as a food crop and because of the fact that large quantities were being imported continually, special efforts were put forth by the Station to solve the problem of adapting this crop to Hawaii. Extensive study was made of the prevalent diseases, which led to the publication of an excellent bulletin (No. 45) in 1920. Also, the trial of many varieties continued, followed by careful selection for developing a type suitable to this tropical environment.

Success began to come as F. G. Krauss on Maui was able to obtain yields of 100 bags per acre and better, of excellent tubers. Disease control seemed to be quite possible and no longer offered the serious threat it once did. But still the growing of potatoes continued on a very small scale and importations increased with the increasing population. There seemed to be no room for potato production; sugar and pineapples had the right of way and were forging ahead in good markets.

In the 1930's, however, both industries suffered reverses from dwindling markets and falling prices. Production, both of sugar and pineapples, was curtailed and large areas of erstwhile busy land became idle. In casting about for some new crop to fill the void, the potato was given a good trial, with encouraging results. The many

years of research which had seemed so futile now enabled the Experiment Station and Extension Service<sup>27</sup> to direct these trials with precision, the planting being confined to early fall and winter so that the crop would come off in time to reach the California market for "new" potatoes and thus command a high price. Even though importation of large amounts of potatoes continues,<sup>28</sup> a partial

<sup>27</sup>Much credit is due, also, to Podmore and Sons, Commission Merchants, for their active work in reviving this industry.

<sup>28</sup>Imports of potatoes into Hawaii in the past several years have been as follows, compiled from the Monthly Summary reports issued by the U. S. Department of Commerce, Washington, D. C.

Year Ending December 31	Volume in Pounds	Value in Dollars	Average Value Per Cwt.
1911 .....	7,674,060	140,037	\$1.82
1912 .....	11,546,340	143,188	1.24
1913 .....	12,885,360	122,450	.95
1914 .....	12,981,600	142,248	1.09
1915 .....	13,907,520	165,878	1.19
Average .....	11,798,976	142,760	1.26
1916 .....	11,352,720	206,020	1.81
1917 .....	11,097,180	306,141	2.75
1918 .....	12,072,900	224,385	1.85
1919 .....	10,784,520	248,403	2.30
1920 .....	9,549,120	347,410	3.63
Average .....	10,971,288	266,472	2.47
1921 .....	18,387,240	317,828	1.72
1922 .....	16,746,300	235,199	1.44
1923 .....	17,013,840	254,041	1.49
1924 .....	16,988,840	324,838	1.90
1925 .....	17,872,560	415,266	2.32
Average .....	17,401,756	309,434	1.77
1926 .....	15,891,720	386,794	2.43
1927 .....	16,670,000	328,956	1.97
1928 .....	16,966,440	215,473	1.27
1929 .....	18,455,520	321,687	1.74
1930 .....	17,490,180	365,969	2.09
Average .....	17,094,772	323,776	1.90
1931 .....	19,504,140	203,420	1.04
1932 .....	19,932,360	179,317	.90
1933 .....	17,829,154	219,095	1.23
1934 .....	16,081,766	189,801	1.18
1935 .....	18,983,547	225,882	1.19
Average .....	18,466,194	203,503	1.11



reversal of the current of trade has begun with exportation of our winter crop at high prices while we import storage potatoes at lower prices. Hundreds of acres have been planted and shipments to the Pacific Coast have been large enough and profitable enough of late years to indicate that there are great possibilities in this crop as a means of diversifying Hawaiian agriculture in an economically sound manner.

For a full treatise on the production of potatoes in Hawaii consult the first publication in the list below, a comprehensive booklet by F. G. Krauss, who chiefly was responsible for the success in re-establishing this industry in Hawaii.

See also "Truck Crops."

Ref.—U. H. Ext. Bul. 15, "Commercial Potato Production in Hawaii," 1931; Haw. Exp. Sta. Bul. 45, 1920; Annual Reports 1901:374; 1902:312; 1903:395; 1906:10; 1913:39; 1914:39; 1915:40; 1916:27; 1917:34, 48; 1918:40, 45; 1925:10; 1926:11; 1927:13; 1936:24, 40. *Planters Monthly* I, 282 (1883); VII, 361 (1888); XII, 314 (1893).

**POULTRY** Chickens were brought to these Islands by the ancient Hawaiians and have for centuries been an important article in their diet. Although raised in confinement, some must have escaped and established themselves in the forests, for even to this day wild fowl are occasionally found.

Poultry raising as an industry, however, did not begin until after the coming of Captain Cook, when he and many other sea captains who came after him bartered for or purchased chickens and eggs from the Hawaiian people. Improvements in the poultry stock of the Islands began not long afterwards by the importation of American and European breeds, and by the end of the nineteenth century there had developed a considerable industry. This was based largely, however, on imported layers, for the "native" stock was inferior in egg production. The 1900 census showed about 95,000 chickens in the Territory, but, if the egg production figures gathered by the census takers can be credited, those chickens were not very prolific, for they seem to have laid an average of only a dozen and a half eggs each per year.

In the 1900's there began to be developed some large poultry plants, and with that the modern industry had its beginning. In 1905 the Hawaiian Poultry Association was formed. With each passing year the number of layers increased, so that in 1930 the census showed more than three times as many as in 1900, with the total egg production about nine times as great, thus indicating that much improvement had been effected in the average quality of the stock.

The income from the poultry industry is nearly a million dollars annually.<sup>29</sup> In 1931 the value of this industry was estimated by the Agricultural Extension Service of the University of Hawaii to be \$998,895.00. During that year this industry was the sixth agricultural income producer for the Territory; not long ago it was regarded by most farmers of the Territory merely as a home source of pin-money for the women and children. The new appreciation for poultry has grown out of the better knowledge of the efficiency of the farm hen in turning feed and labor into substantial profit and income. Poultry has been the means of carrying many a hard-pressed family through financial stress, and has finally emerged as an established industry.

Although the poultry industry has made great advances during the past 30 years, it still has a long way to go in its development program. Hawaii is still importing each year more than two million dozen eggs valued at approximately \$500,000.00, as well as more than a million pounds of poultry valued at more than \$200,000.00. These imports might well be replaced by eggs and poultry of local production.

The per capita rate of egg consumption is increasing in Hawaii, but is still considerably below that of the mainland, being about 12 dozen per year per person here compared with 25 dozen in the states.

Through the efforts of poultry producers and especially of our Experiment Station and Extension Service, the industry here has been put upon a more sound basis than was true in 1910 or even 1920. Diseases formerly

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<sup>29</sup>This and the following paragraph are taken from Bulletin 20 of the Agricultural Extension Service of the University of Hawaii, 1934, by H. L. Chung, A. S. T. Lund, and C. M. Bice.

took a very heavy toll but now do not; in the earlier time practically all layers were imported, but now only a few breeders are brought in and all layers are locally produced; it used to be thought that in the tropics 100 eggs per year was as good a record as could be expected, but now we have our 300-eggers and our hens can compete in this regard with the best anywhere in the world, as proved in several egg-laying contests conducted here under standard rules and techniques.<sup>30</sup>

The cost of feeds remains a serious problem, for Hawaii produces no cheap cereals and must rely on imported concentrates until suitable substitutes can be found. Some progress is being made in this line, but not enough to bring our egg prices down to an equality with the mainland product where cheaper feeds are available.

Anyone desiring full information about the poultry industry, the selection of breeds, the problems of feeding, marketing, etc., should consult first the University bulletin referred to above in a footnote; also, the following bulletins are of importance:

Ref.—Haw. Exp. Sta. Circ. No. 1, "The Management of Baby Chicks in Confinement"; No. 3, "Natural and Artificial Incubation of Hens' Eggs"; No. 4, "Poultry Feed Supplements"; No. 5, "Poultry Diseases Common in Hawaii"; No. 7, "Capon and Caponizing"; No. 8, "Fowl Pox (Sorehead) Control By Vaccination"; No. 10, "Turkey Management In Hawaii." Annual Report 1936:73-82 (diseases, feeds, etc.).

**PRIDE OF INDIA** The Pride of India, also known as Oriental Lilac (*Melia azedarach*) is a common ornamental tree throughout the Hawaiian Islands, with little or no commercial value associated with it.

At one time it was recommended for wide planting as a source of fuel wood, with the further possibility of being valuable for timber purposes.<sup>31</sup>

**PULU** See "Tree Fern."

**PUMPKIN** See "Squash."

<sup>30</sup>For detailed reports upon these egg-laying contests see Annual Reports of U. H. Agr. Dept. 1924:43-46; 1925:29; 1926:49; 1927:24-27; 1928:25-27; 1929:23-24.

<sup>31</sup>Trans. Royal Haw'n Agr. Soc., Vol. I, No. 2, p. 83 (1851).

**PYRETHRUM** Pyrethrum, or buhach, is an insecticide powder made from the flowers of certain chrysanthemums (*Ch. coccineum* and *Ch. cinerariaefolium*). In 1909 an attempt was made to establish a small industry based on the cultivation of these plants.<sup>32</sup> Dr. A. Marques obtained seed from Algiers and requested the cooperation of the Hawaii Experiment Station and several individual gardeners in trial plantings. Although these experiments were successful in demonstrating that the plants would grow here, nothing of importance developed out of them.

A renewed effort is now being made to establish the cultivation of this plant as an industry here. The Agricultural Extension Service of the University recently obtained seed from Colorado and several experimental plantings in various parts of the Territory are under observation. Because, however, of the large amount of hand labor involved in the harvesting and handling of this crop, it is not likely that in a high-wage country like this the industry could develop into anything of large importance.

Pyrethrum plants are perennials, flowering at the end of the first year and bearing increasingly large crops of flowers in each successive year for 6 to 12 years.

See also "Derris."

Ref.—Thrum's Annual 1910:101-105.

**QUINCE** The quince (*Cydonia vulgaris*) is a temperate zone fruit which is occasionally grown in Hawaii at relatively high elevations (4000 feet and above) where the cool climate is favorable. Fruits of good quality are sometimes exhibited at county fairs, but the quince is not considered as offering any promise for commercial exploitation here.

**QUININE** See "Cinchona."

**RABBITS** Rabbit raising as an industry is very old in some parts of the world, but did not have a beginning in Hawaii until some seventy-five years ago. There was a small importation of rabbits into these Islands, perhaps

<sup>32</sup>Twenty years prior to this there had been a show of interest but no serious effort was made to establish the cultivation of the plant. *Planters Monthly* VIII, p. 256 (1889).

the first, in 1853, and in 1873 permission was granted to use a small islet near Hilo for rabbit propagation. Rabbit raising has never, however, rivalled the poultry industry in size anywhere, always being relatively insignificant. In Australia, where rabbits have escaped and become very plentiful, an industry has been developed in the last two decades in the canning of the meat.

In Hawaii one must obtain permission from the government to raise rabbits, whether as pets or for commercial purposes, a rule imposed by the Territorial Board of Agriculture and Forestry as a protection against the escape of these animals and their propagation in the wild, to the detriment of agriculture and forests.

As a means of increasing and diversifying the home food supply and perhaps also increasing the family income, rabbit raising on a small scale offers attractive possibilities, especially in rural and suburban districts. Anyone desiring detailed information on the subject, as to suitable breeds and correct methods of procedure, should consult Bulletin 12 of the Agricultural Extension Service of the University of Hawaii, 1931, by H. L. Chung.

**RADISH** The small table radish (*Raphanus sativus*) is a very widely cultivated crop in market and home gardens but the total production is small, nevertheless, for the consumption per capita is exceedingly limited. The fleshy root, usually eaten raw, is used as a relish because of its peppery flavor.

The Japanese and Chinese have a special variety of radish, known as *daikon*, the root of which is elongate in shape and much larger than the other varieties and instead of being eaten raw is either cooked or pickled.

Daikon production in Hawaii occupies a part of many vegetable gardens, amounting in the aggregate to over 50 acres, according to a 1936 survey of crops. Other varieties of radish occupy probably less than 5 acres.

The tops of young radish and daikon plants are commonly used by Orientals as cooked greens. The ordinary planting practice is to seed heavily and later thin out the rows of seedlings. The seedlings thus eliminated

are saved and marketed as greens.<sup>1</sup> Their mild peppery flavor makes them very delicious.

See also "Truck Crops."

**RAMIE** Ramie fiber, sometimes called "China grass," is well known in commerce and is much in demand for cordage and other uses. It is made from the bark of a plant (*Boehmeria nivea*) somewhat related to the Hawaiian olona.

Production of this fiber plant in Hawaii was begun in the early 1880's in a small experimental way, in the hope that it might be the means of diversifying industry here which was thought to be too much centered on one crop. The experimental plantings were sufficiently successful to arouse much interest and great hopes. There was, however, a serious obstacle to successful establishment of an industry in that no machine had been developed for the separation of the fiber of this plant, for it presented certain mechanical difficulties not encountered in the case of most other fiber plants. To overcome this obstacle the Hawaiian government in 1884 offered a reward of \$10,000 for the perfection of a machine suitable for making ramie fiber. The Hawaiian Ramie Company made such a machine and claimed the reward in 1886. Although it was conceded that the invention merited the reward, the government found itself unable to pay the money.<sup>2</sup> The company continued its operations, however, and popular interest was strong in this incipient industry, though not strong enough to prompt planting on a large scale. The first machine did not, after all, prove to be successful, and another was brought out by J. C. White, of Honolulu, in 1892. Interest, which had waned somewhat, now arose again, but only for a short time. The plantings were soon abandoned and attention turned to sisal as a more promising source of fiber.

Ref.—Planters Monthly Vol. II, 228 (1884); III, 394, 464, 669; IV, 5, 35, 141, 152, 156; V, 26, 248; VI, 111; IX, 516; X, 332 (1891). Thrum's Annual 1893:107. Haw. For. Agr. 1904:140-149 (good treatise on cultivation and extraction of fiber). Hon. Advertiser, Dec. 15, 1935 (statement on editorial page).

**RANGE GRASSES** See "Grasses."

<sup>1</sup>Haw. Exp. Sta. Bul. 60, p. 22, 1929.

<sup>2</sup>Planters Monthly V, p. 133 (1886).

**RASPBERRY** At elevations of 3000 to 5000 feet above sea level certain varieties of the common raspberry (*Rubus spp.*) do fairly well in Hawaii, but thus far the results do not give much promise for successful production on a commercial scale.

The Hawaii Experiment Station obtained plants of some 19 different varieties from mainland states in 1929 and 1930; while several made some growth, none prospered, regardless of whether they were planted at an elevation of a few hundred feet or over 2000 feet above sea level.

See also "Akala."

Ref.—Haw. Exp. Sta. Annual Report 1929:19; 1930:26; 1931:23; 1933:10.

**REDTOP GRASS** Redtop grass (*Agrostis alba*) is very widely distributed on Hawaii Island and less so on the other islands. It was introduced by David M. Forbes in the 1880's. Used in grass mixtures it is good on poor, thin soils.

Ref.—Haw. Exp. Sta. Bul. 65:3, 1933.

**RHODES GRASS** Rhodes grass (*Chloris gayana*) is considered very valuable on all ranches, as it furnishes abundant grazing and does well under a variety of conditions. It is sometimes used for hay.

Ref.—Haw. Exp. Sta. Bul. 65:13, 1933.

**RHUBARB** Rhubarb (*Rheum Rhaponticum*) is grown only to a limited extent (perhaps an acre or two) in Hawaii, as it requires a cool climate. In Waimea, Island of Hawaii, it does well and at corresponding elevations where there is ample rainfall and well drained soil farmers would be wise to produce this crop for market,<sup>3</sup> for Honolulu imports some 60,000 pounds per year from the mainland.<sup>4</sup>

The edible portion of the plant is the thick, succulent petiole which has a pleasant acid flavor and may be

<sup>3</sup>For directions in planting and cultivation see Agr. Ext. Bul. 16, 138, 1932.

<sup>4</sup>According to Mr. Jared Smith, the Honolulu market was well supplied some years ago by W. H. G. Arnemann, who cultivated rhubarb at Alike (Hawaii) until the 1919 lava flow destroyed his land.

cooked in a number of ways. The leaves are good when cooked as greens.

See also "Truck Crops."

**RICE** Rice (*Oryza sativa*), the food staple of the Orient, was a "luxury from abroad" in Hawaii in the first half of the nineteenth century. In 1853 a Kauai agriculturist noted the fact that \$10,000 to \$12,000 was being spent each year for rice imported from China "which might readily be raised here." (That has a familiar and modern sound to it!) The Royal Hawaiian Agricultural Society began some experiments, using seed from South Carolina introduced by Holstein, and found that rice could be grown here successfully, and from then there developed a considerable industry in the production of this crop. Before long there was enough to supply all local needs and Hawaii became a rice exporting country. The peak was reached in 1887 when over 13 million pounds were exported.

It was in that period, the second half of the century, that Chinese immigrants were coming into Hawaii by thousands and they not only created a large local market for rice but, also, went extensively into its production. Nearly all the rice growers were Chinese, and they used here the same production methods that had been used in China for centuries.

By the end of the century there began to be a decline in this industry, for cheaper and better rice was coming in from Japan and also from Texas and Louisiana, and later from California. In 1901 these imports amounted to about 250,000 pounds, which was just the beginning of the flood that was to come in a few years to swamp local producers.

During the past forty or fifty years this industry has been suffering a slow but steady decline, due to several factors:

(1) Sugar was proving to be more profitable and was therefore taking away some of the acreage once used for rice.

(2) The coming in of thousands of Japanese turned a very large part of the demand to Japanese rice, as it was considered by them to be superior to Hawaiian grown rice.



(3) The higher wage level here made it impossible to compete with rice produced in Asia where wages were much lower, and the antiquated methods used here made it impossible to compete with the American-grown product of Texas, Louisiana and California. In other words Hawaii was trying to produce rice by Oriental techniques at American wages, and naturally was finding it practically impossible to meet outside competition.

In 1906 the Hawaii Experiment Station began to try to do something for the failing industry. F. G. Krauss was taken from Kamehameha Schools and put in charge of an extensive series of experiments to find some variety of rice that would be better than the one commonly grown here, and to develop better methods of cultivation. The Station had 130 kinds under test within a year or two and one especially promising variety seemed to be emerging. In 1907 a survey of the Hawaii rice industry was made and it was found that it occupied about 10,000 acres and returned about \$2,500,000 annually to the Territory. The sugar industry at that time was returning about \$30,000,000, while the infant pineapple industry had not yet reached the one million mark in its value to the Islands. Rice was the second industry in the Territory.

For several years the work of the Experiment Station stimulated a renewed interest in the industry of rice production, and for a time its downward movement was somewhat checked. Since the Japanese seemed to insist on their own kind of rice, seed was brought in from Japan to be used instead of the Hawaiian seed. But after a few years it was announced by the Experiment Station that the results were not up to expectations. The preference for Japanese rice was said to be due not to its flavor but to certain physical qualities, and it was claimed that even when Japanese seed was used the Hawaiian-grown product did not have the same characteristics in that respect as the rice grown in Japan. It developed later, however, that Japanese seed grown in California was acceptable to the Japanese in Hawaii, perhaps because it was a little cheaper; California thereby captured most of our rice market, which now absorbs about two-thirds of the total output of California.

By 1915 the revival of interest in this industry had be-

gun to wane, for the local producers would not change their old methods of cultivation, and the market seemed to be steadily slipping away to the importers. As the old Chinese planters died, the younger generation was not taking their places, and the acreage was diminishing. In 1920 a survey indicated only about 6200 acres in rice, while a decade earlier it had been 10,000.

In 1928 a new insect pest, the rice stem borer, appeared on the scene and caused a great deal of havoc in the dwindling industry. Many fields were abandoned because of this insect. This may prove to have been the last blow to kill the rice industry in Hawaii, for today there are less than 2000 acres throughout the entire Territory devoted to this crop. We import and consume annually over 92,000,000 pounds compared to our local production of about 4,000,000 pounds. Imports from California in 1919 and 1920 about equaled the amounts produced in the Territory, but by 1932 the latter had declined to such a low figure that local production amounted to only about 4 per cent of the total consumption, nearly 96 per cent coming from California.

The reasons for its failure to become permanently established in our economic structure are several:

- (1) High production costs.
- (2) Antiquated methods of cultivation.
- (3) Lack of suitable land areas where modern, large-scale production methods could be used.

At the present time there is a movement under way to build up the rice industry on new and modern lines, using more machinery in planting and harvesting and applying fertilizers judiciously. Kauai is leading in this movement, which may bring important results in the next few years. Much will have to be done, however, to place production here on a cost basis equal to California; a recent comparison by the Hawaii Agricultural Extension Service showed production costs on Kauai nearly three times as high as California production costs per 100-pound bag.

A dry land variety of rice was planted experimentally in 1918 at the University farm to ascertain the possibilities of this as a forage crop for livestock. The results were not

encouraging and the test was not repeated. (U. H. Agr. Dept. Ann. Rep. 1918:9.)

Ref.—Thrum's Annual 1877:45-49 (History of Rice Industry); 1912:128-132; Haw. Exp. Sta. Annual Reports 1901:377; 1906:15; 1907:21, 67; 1908:14, 65; 1909:14, 63, 66; 1910:12; 1911:54; 1912:64, 75; 1913:35; 1914:36; 1915:39; 1918:46; 1920:37; 1928:14. Bul. 21 (Composition of Rice Plant), 1910; 24 (Assimilation of Nitrogen), 1911:31 (Rice Soils), 1914; Press Bul. 19 (1907). U. S. D. A. Year Book (statistics). Koamalu, several references to rice culture.

**RICE BRAN** The milling of rice yields a by-product comparable to a combination of wheat bran and middlings and is called rice bran. It has excellent nutritive values both as human food and for livestock as well. The nutrition laboratory of the University has investigated the vitamin content and food value of this product for humans and recommends that it be used as an additional ingredient in bread. A local bakery has taken up the suggestion, but the limited supply of rice bran available in Honolulu has not permitted as great an exploitation of the idea as it deserves.

Some tests of rice bran in comparison with wheat middlings as a feed for hogs at the University farm showed the greater food value to be in the latter.

Ref.—U. H. Agr. Dept. Annual Report 1924:18.

**RICE GRASS** Rice grass, or laiki grass (*Paspalum orbiculare*) is good for poor thin soils but elsewhere is not equal to the better pasture grasses.

Ref.—Haw. Exp. Sta. Bul. 65:36, 1933.

**ROSE APPLE** The rose apple (*Eugenia jambos*) is an attractive tropical tree not infrequently grown as an ornamental. Its fruits are about the size and shape of a small guava. The flavor is suggestive of the aroma of a rose. Although it is relished by most people, this fruit is not produced on a commercial scale and rarely if ever comes into the markets.

Ref.—Wilder, "Fruits of Hawaii" (1906), p. 28.

**ROSELLE** Roselle (*Hibiscus sabdariffa*) is a small shrub closely related to the common garden hibiscus, producing flowers with succulent calyx of a pleasant flavor, which are useful in the making of jelly.

The plant is commonly cultivated in Mexico and the West Indies, where it is used primarily in the making of a refreshing drink. The Hawaii Experiment Station imported seed from Porto Rico in 1904 and maintained a small area for several years thereafter as a demonstration of the possibilities of this crop for Hawaii, especially for jelly-making. In 1913 a considerable interest developed in this plant as a quick cash crop to be planted between rows of young rubber trees on Maui. Also, in Kona there were a number of commercial plantings, the total area there and at Nahiku (Maui) at one time amounting to over 200 acres.

Disappointment came, however, when the expected market for jelly making did not materialize and the growers were obliged to resort to drying the crop for export to the mainland, where only a moderate demand existed. The returns were not encouraging and the young industry languished.

Now, except for occasional garden plantings here and there, the roselle no longer appears in the agricultural scene.

Ref.—Haw. Exp. Sta. Bul. 47, "Principles of Jelly Making," p. 17-20, 1923; Annual Reports 1906:10, 34; 1907:56; 1914:52; Haw. For. Agr. 1906:425-428 (J. E. Higgins).

**RUBBER** The meteoric rise of the automobile industry in this century developed a great demand for rubber. At the beginning of the century American imports of rubber from various tropical regions amounted to less than 40,000 tons per year, while by 1934 they had risen to over 600,000 tons. World production in that period increased from about 50,000 tons to over a million.

Rubber is extracted from the latex of a large number of plants, most of which grow only in the tropics. Several species have become commercially established as the chief producers of rubber, notably the *Hevea* in Brazil, the *Castilloa* in Central America, the *Ficus* in India, and the *Ceara* (*Manihot glazioviana*) in South America. Some of these were brought into Hawaii in the 1890's, a small grove of Ceara having been planted on Kauai in 1893.

In 1905 there came a wave of popular interest in rubber production as a possible industry in Hawaii, for the price of the commodity was mounting higher as the automobile

manufacturers began bidding up for the relatively small supply available in the world. At that time it was obtained by going into tropical forests and tapping the trees. The idea of cultivating rubber trees in a plantation was unheard of, as the natural supply in the forests had always been ample.

Two companies were organized here in 1905 to produce rubber, and the Hawaii Experiment Station began a program of research in that year which continued for over a decade. The little grove of Ceara rubber trees which had been planted on Kauai in 1893, even though they had been badly neglected, furnished a means of testing the yielding qualities of this species under Hawaiian conditions. As the results seemed promising, capital came out in fair abundance.

The Nahiku Rubber Co. was incorporated in 1905 with a capitalization of \$150,000, obtained a tract of 900 acres of land on Maui (Nahiku) and began planting operations at once. A six years test of Ceara rubber trees in that locality had preceded the establishment of this company, so that it was not a venture in the dark. By the end of 1906 the new plantation had 11,200 Ceara trees from 1 to 15 feet high, 14,860 *Hevea braziliensis* and 500 Castilloa, with many thousands of seedlings of these several species for future planting.<sup>5</sup> The other company, the Koolau Rubber Co., had about 10,000 trees on 25 acres, with larger plans ahead. A third company, the Puna Development Co., also had a hundred or more acres in rubber.

The price of rubber was then about \$1.00 per pound, and in the next few years went even a little higher than that. This was high enough so that the relatively high labor costs here did not worry the planters. At first it cost nearly half the market price to tap the trees and harvest the latex, but in a few years they were able to bring down the harvesting cost to about 25 cents per pound. Of course, in practically all other rubber-producing countries this item was much lower, for none was paying a dollar or more per day to their workers as Hawaiian producers had to do.

As several rubber-producing companies were being established in the first decade of this century, it was natural

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<sup>5</sup>Thrum's Annual 1906, pp. 155-6.

that an association of rubber producers was formed, with headquarters in Wailuku, Maui. Maui seemed to be becoming the rubber island. The outlook seemed very promising until 1912 and 1913 when the price of rubber dropped to a relatively low point because of great increases in world production. Hawaii was naturally the first to suffer, because of high wage costs, but persisted to 1915, when this industry, which had been flourishing so well, practically dropped out of sight. The extent to which the industry developed is shown in the following tabulation of exports, from Thrum's Annuals:

<i>Year</i>	<i>Value</i>	<i>Year</i>	<i>Value</i>
1908 .....	\$2,656	1912 .....	\$3,811
1909 .....	3,746	1913 .....	5,993
1910 .....	7,938	1914 .....	2,743
1911 .....	60 <sup>6</sup>	1915 .....	1,705

This experience illustrates well Hawaii's limitations in industrial development. We had climatic conditions suitable for several of the species of rubber-producing trees and undoubtedly we could have done as well as any other country, especially with Ceara, which was the most promising of all the rubbers for these Islands. But climate and soil do not, alone, determine the results. The wage rate is a factor of great importance, especially in handling a crop which requires so much hand labor. It is true that our rubber planters made excellent progress in reducing production costs, not by reducing wage rates, but by increasing the efficiency of laborers. At first the average rate of latex harvesting was two pounds per man-day, but by 1910 this had been doubled. And in certain instances it was increased to nine pounds per man-day. Even at that level it represented a pretty high labor cost if the price of rubber should drop materially, as it did soon after.

The planters were not satisfied even with nine pounds per man-day. The Experiment Station experts found a way to propagate the rubber trees from cuttings taken from the best producers; individual rubber trees, like all other living things, differ among themselves in the vigor of growth and the rate at which they yield, and it was found that by propagating vegetatively instead of by planting

<sup>6</sup>Evidently the 1911 sales were credited mostly to the preceding year by the statistician.

seeds a rubber plantation could be developed which would surpass anything theretofore conceived of. In fact, small scale operations on this plan proved in 1914 that the labor cost of harvesting rubber latex could be brought down to 6 cents per pound, with 17 pounds of rubber gathered per man-day. Of course, there are other cost items which have to be added to this, as the maintenance of the plantations, the manufacture of crude rubber from the latex, etc. These, it was estimated, would amount to 20 to 30 cents per pound, to which the 6 cents cost of gathering the latex would have to be added.

Any crop which cannot be handled largely by mechanical means has little chance of becoming the basis of a large industry in a high wage country, as Hawaii.<sup>7</sup> In considering possible ways of diversifying our present agricultural industry this basic fact must be kept in mind.

See also "*Euphorbia lorifolia*."

Ref.—Haw. Agr. Exp. Sta. Press Buls. 13 (1905), 44 (1913); Bul. 16 (1908), 19 (1910); Annual Rep. 1905:22; 1906:12; 1907:19; 1908:11; 1909:15; 1910:17; 1912:88; 1914:51; Haw. For. Agr. 1904:287-294 (Kidwell); 1905:255-260 (R. H. Anderson, on possibilities of industry in Hawaii).

**RUSHES** See "Matting Sedges and Rushes."

**RUTABAGA** The rutabaga (*Brassica campestris napo-Brassica*) is very similar to the turnip and in the market here usually passes as a turnip. It may be distinguished by the purplish color of the exterior.

See "Turnip," also "Truck Crops."

**RYEGRASS** Italian ryegrass (*Lolium multiflorum*) is considered very valuable on the Parker and Shipman Ranches.

Ref.—Haw. Exp. Sta. Bul. 65:26, 1933.

**SABUCAIA** See "Sapucaia Nut."

**SALSIFY** Salsify (*Tragopogon porrifolius*) is only sparingly grown in Hawaii, not because of any unfavorable climatic conditions but because the demand here is very small. The edible portion of the plant is its long,

<sup>7</sup>An exception to this is any crop which commands a very high unit price in the winter months when our freedom from frost makes it possible to produce. Even with high labor and overhead costs such production may pay well during a limited season.

tapering, fleshy tap-root, which on being cooked has a flavor remotely suggestive of oysters.

See "Truck Crops"; also, "Burdock."

**SALT** Although not an agricultural industry, salt production may be mentioned as an art developed by the ancient Hawaiians. Sea water was evaporated in earth basins and the resulting crystallized salt, of a reddish color, was used to season food and preserve fish.

In spite of large imports there is still a considerable demand for this locally made salt.

Ref.—Thrum's Annual 1924, pp. 112-117.

**SALTBUSH** Saltbush is the name applied to several species of plants of the genus *Atriplex*, which grow habitually in low flats along sea margins. The foliage is somewhat succulent and makes acceptable feed for livestock in areas where better forage plants would not grow.

In the 1890's an Australian species of saltbush, *Atriplex semibaccata*, was introduced by Tom Gay and established at Mokuleia (Oahu). A few years later it was taken to Molokai by G. C. Munro<sup>1</sup> and has become well distributed over that Island. F. R. Fosberg<sup>2</sup> reports this species as being of general occurrence in the Territory, disseminated probably by birds.

Several other species have been introduced and two have become established: *Atriplex rosea*, *Atriplex lentiformis* (the Arizona saltbush).<sup>3</sup> Three species introduced from Australia by the Hawaii Experiment Station<sup>4</sup> about 1907 (*A. nummularia*, *A. leptocarpa* and *A. halimoides*) seem not to have established themselves here, as they are not reported by botanists.

**SANDALWOOD** Sandalwood (*Santalum freycinetianum*), now a rare and high-priced forest product, was once the basis of a lucrative industry in Hawaii. From about 1790 to 1840 varying quantities of this valuable and fragrant wood were shipped to China, the total in some years amounting in value to over \$100,000, while in one

<sup>1</sup>See Haw. For. Agr. Vol IV, p. 248 (1907).

<sup>2</sup>Univ. Haw. Occ. Papers. (As yet unpublished).

<sup>3</sup>This was introduced from Arizona by G. C. Munro in 1900 or 1901. [See Haw. Agr. For. IV, 248 (1907).]

<sup>4</sup>Haw. Exp. Sta. Annual Report 1914:39.



period of 18 months it yielded \$400,000. The forests in time became stripped of this species of tree, however, and in the 1830's the industry declined, exports in 1836 being about \$26,000, in 1837, \$12,000, in 1838, \$6000, and nothing after 1840.

Thereafter, until the beginning of the present century, sandalwood in Hawaii was merely a memory, for it was almost extinct throughout all the islands. In 1904, however, the Territorial Board of Agriculture and Forestry began giving some attention to the replanting of this valuable tree in the mountain forests. Although no great amount of effective planting resulted for a number of years, in the 1930's many thousands of young trees were planted which in due time may become the means of reviving a long dead industry. It is safe to predict, however, that when that time comes the exploitation of this resource will not be as wastefully managed as once was the case.

Ref.—Thrum's Annual 1905, pp. 43-74 (an excellent account of "The Sandalwood Trade of Early Hawaii," by Thos. G. Thrum); 1933:81-88 (C. S. Judd). Haw. For. Agr. 1927:42-43 (C. S. Judd); also, Botanical Bul. 3, by J. F. Rock, 1917.

**SANSEVIERIA** Bowstring hemp is the fiber of the leaves of *Sansevieria*, a tropical plant which grows very readily and successfully in Hawaii, resembling somewhat the pineapple plant in general appearance. Its leaves can be harvested periodically for ten years or more without the necessity of replanting the fields. The fiber is of good quality and readily marketable.

An effort was made in 1893 by the Bureau of Agriculture of Hawaii to establish an industry on this plant, as it was then receiving attention in Florida. No results of commercial importance followed, however, and the plant has remained to the present an interesting feature in many gardens but not exploited industrially.

**SAPODILLA** See "Sapota."

**SAPOTA** The sapota (*Achras sapota*) is a relative of the custard apple. It is a tropical tree, introduced here from Central America many years ago, and grown occasionally as an ornamental. The fruit is about the size of a small apple, somewhat rusty in color; its outer skin is rough and leathery, and its pulp inside divided into a

number of compartments, like the custard apple, each with a black seed. The flavor is pleasant, suggestive of the apricot. Chewing gum may be made from the hardened latex. There is no commercial exploitation of this fruit in Hawaii.

Another species of tree (*Casimiroa edulis*) produces a fruit somewhat similar to the foregoing and is known in tropical countries as the white sapota. It is uncommon in Hawaii, and is used only as an ornamental.

Ref.—Kuck and Tongg, "The Tropical Garden," p. 145; Bryan, Nat. Hist. Hawaii, p. 266.

**SAPUCAIA NUT** The sapucaia nut (*Lecythis zabucajo*) is related to the common brazil nut and is produced on a large tree indigenous in the Amazon Valley of South America. This nut is believed to be superior to the brazil nut, but is not much known in the American market.

A few trees are growing on Kauai, and a few on the Kona lands of the Hawaii Experiment Station. As yet, no commercial importance has been attached to them in Hawaii.

**SATSUMA ORANGE** See "Tangerine."

**SEDGE** See "Matting Sedges."

**SHADDOCK** See "Grapefruit."

**SHEEP**<sup>5</sup> The first sheep in Hawaii were brought here by Vancouver in 1793, and a second lot a year later by the same sea captain. They were allowed to run wild and multiply, but there was no great commercial exploitation of these animals until about a half century later. In 1845 some Merino rams were brought in to improve the flocks and with that the sheep growing industry in Hawaii may be said to have begun. Other importations followed in the succeeding ten years, the new stock coming from various parts of the world.

Until 1852 the entire interest in sheep here had been as a source of meat, but in the 1850's the Royal Hawaiian Agricultural Society turned the attention of sheep raisers to the great possibilities in the production of wool.

Sheep ranches were established in various parts of the

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<sup>5</sup>In the preparation of this statement Prof. L. A. Henke has collaborated.

Islands, one on the Waimea plains about 1856 by Frederick Low, and others on Molokai, Lanai and Niihau. By 1875 wool production had reached a relatively high point of development here, the clip having been 565,469 pounds that year, from which there was a return of about \$70,000. In subsequent years this industry has had its ups and downs; in 1878, for example, the clip was only 243,740 pounds, but in other years it amounted to 400,000 and 500,000 pounds.

The sheep industry of Hawaii apparently reached its high point about 1884, and there has been a decline since that time as is shown below:

<i>Year</i>	<i>No. of Sheep</i>
1879 .....	101,726
1884 .....	121,683
1895 .....	93,312
1900 .....	102,098
1910 .....	76,710
1920 .....	44,042
1930 .....	32,256

Sheep were important on Molokai Ranch thirty years ago, as many as 17,000 being reported for the year 1907, but at present only a few hundred are found on Molokai.

The sheep industry at the present is concentrated at the Humuula sheep station of the Parker Ranch located on the saddle between Mauna Kea and Mauna Loa, where about 12,000 Merinos are kept, and on the Island of Niihau. Three thousand sheep were carried from Molokai to Niihau in 1864, according to Interior Department letters in the Archives of Hawaii.

Sheep in Hawaii are at present kept largely for wool production and not much lamb is locally produced. The demand for the mutton that is produced is small, usually at an unprofitable price.

Imports of fresh mutton and lamb during recent years follow:

<i>Year</i>	<i>Pounds</i>	<i>Value</i>	<i>Per cent from Foreign sources</i>
1920 .....	290,772	\$ 26,607	100.0
1923 .....	462,270	65,660	96.5
1926 .....	401,719	58,513	92.3
1929 .....	692,871	103,438	92.5
1932 .....	789,670	91,799	3.7
1935 .....	891,773	140,006	.0

The following tabulation of wool exports during the past 30 years shows rather wide fluctuations, which are quite as much due to price as to the size of the clip:

<i>Year</i>	<i>Value</i>	<i>Year</i>	<i>Value</i>
1905 .....	\$ 53,558	1921 .....	\$101,756
1907 .....	54,548	1922 .....	15,726
1908 .....	58,133	1923 .....	117,818
1909 .....	52,448	1924 .....	42,835
1910 .....	56,425	1925 .....	73,772
1911 .....	53,140	1926 .....	63,210
1912 .....	61,780	1927 .....	70,486
1913 .....	71,113	1928 .....	45,735
1914 .....	77,214	1930 .....	16,112
1915 .....	70,971	1931 .....	44,302
1916 .....	31,152	1932 .....	28,620
1917 .....	27,395	1933 .....	57,448
1918 .....	81,805	1934 .....	50,000
1919 .....	96,842	1935 .....	42,121
1920 .....	138,673		

Ref.—U. H. Research Publ. No. 5, pp. 16-18 (Henke, "Survey of Live-stock in Hawaii" 1929). Thrum's Annual 1903:54; 1906:45, and subsequent issues for tabulation of exports.

## **SHELL BEANS** See "Beans."

**SILK** Contrary to general belief, rayon has not pushed silk out of the market. It caused the price of silk to decline very greatly, and probably is responsible for a small drop in American imports, but silk is still much in demand. American imports of silk in 1909 were 23 million pounds and were increasing steadily until 1929, when they reached the peak of 90 million pounds. By 1934 imports were down to 70 million pounds, but that was a large amount considering that rayon production in our country had jumped from 40 million pounds in 1924 to 210 millions in 1934. While rayon has not caused any great decrease in our silk imports, it (with other factors) brought the price of raw silk tumbling down from \$6.00 per pound in 1924 to \$1.20 in 1934; current prices fluctuate around \$1.90 to \$2.00 per pound.

Silk worm culture is carried on in many countries both in Asia and Europe, but not much in America. Some sporadic efforts have been put forth during the past hundred years to make Hawaii a silk producing country, but thus far with no success.

The first commercial venture in silk in Hawaii was in 1836 at Koloa, Kauai. Two partners, Peck and Titcomb,

leased a tract of 400 acres for experiments in producing cotton, coffee and silk. On adjoining land, the firm of Ladd and Company was developing the Territory's first successful sugar plantation. Here, then, were four potential industries struggling to be born, of which two were more or less successful: sugar and coffee.

The mulberry, planted to furnish feed for the silk worms, did exceedingly well at Koloa and the partners soon had a large area under cultivation. To this day the hill on which those mulberries grew, nearly a century ago, bears the name of Mauna Kilika, which is Hawaiian for Mt. Silk.

Commenting on this early attempt to found an industry, Ethel Damon says in her "Koamalu"<sup>6</sup> (p. 181) that, "it was thought that the care of cocoons might well employ Hawaiian women and children." Again (p. 331), she observes that as silk culture began to get under way "Hawaiians had now some means of profitable labor by which they could free themselves from the restrictions of the Konoiki, or overlord."

But troubles beset the new industry, first in the extreme irregularity of the hatching of the silkworm eggs. As young worms must be fed and treated differently from older worms, this irregularity of hatching made the handling of the worms very difficult and expensive. Occasional droughts, also, handicapped the pioneers by causing a shortage of mulberry foliage.<sup>7</sup> By 1840 the silk part of the Koloa venture was declared a failure, and one of the partners (Titcomb) transferred his efforts to the other side of Kauai, at Hanalei, where for several years a small industry was maintained. The first export of silk was in 1844, and was rated as being of fairly good quality. The industry did not persist long, however, for "the profits were too slow to warrant the necessary outlay of capital" (Damon, in "Koamalu," p. 332), and by the middle of the century the culture of silk worms on a commercial basis was abandoned.

A revival came after a half century, however, for in

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<sup>6</sup>Privately printed in Honolulu in 1931.

<sup>7</sup>Another obstacle sometimes cited was the fact that the worms had to be fed on Sundays and Sunday labor was supposed to be tabu by the newly adopted Christian teachings. This probably had little or nothing to do with the failure of the industry.

1905 the Hawaii Experiment Station began some trials which ran for three years, then faded out of the picture. Eggs were brought in from Europe (through Washington, D. C.), Japan and China, and several trial lots of cocoons were produced and sent to the U. S. Department of Agriculture for testing. The reports were good; the silk was of very good quality. The general results of three years of investigations led the Station entomologist, D. L. Van Dine, to declare in 1907 that "silk of good quality can be produced with as little effort in Hawaii as in any other silk-producing country." He might have added, however, that the same effort in Hawaii demands a considerably higher wage rate than in the other silk producing countries.

An important factor influencing the Hawaii Experiment Station to undertake these studies was the presence here of large numbers of Oriental plantation laborers and their families who, it was believed, would welcome an opportunity to increase their incomes by rearing silkworms outside of plantation hours. "If Hawaii is to succeed in holding the laboring class to the soil, the industry of silk culture is worthy of receiving serious consideration," says the 1907 Annual Report (p. 42) of the Station.

The mulberry, necessary as feed for silkworms, grows very successfully in Hawaii. In most respects the climate here is favorable to silkworm culture. The evenness of our climate makes it possible to raise worms throughout the entire year, whereas in most other producing countries the industry is seasonal. There are some disadvantages, as the humidity of our atmosphere, but these are offset by certain advantages.

There is no doubt that good quality silk can be produced here, for it has been done on several occasions and the results checked by competent experts.

The principal obstacle to developing a silkworm industry here has been the cost of labor. So long as the usual methods are employed in the rearing of the worms and handling of the cocoons there is a large amount of expert labor required. Even though a large part of this work were done by women and children, still the cost would be much higher than in Japan or China because of the very large differential in wage rates and living costs.

Hawaii could not possibly compete with the Orient in any industry requiring much hand labor.

This does not mean, however, that there is no hope for a silk industry in Hawaii. Such an industry might be developed here very successfully if a large part of the expensive hand labor could be eliminated by the substitution of machinery. That the culture of silkworms can be handled in this way is not merely a hypothetical idea but a reality, for it is being done in a small way in California. One man has mechanized most of the processes, from growing and harvesting mulberry foliage to the feeding of the worms and keeping their trays clean and preparing the cocoons for reeling.

If Hawaii ever develops a silk industry it will be on some such basis as this. It would seem that a good trial should be made, for we have excellent conditions in our natural environment, and our people are accustomed to doing things by the use of machinery and scientific research. If, by this method, silk could be made profitably at present low market prices, the future would seem to be comparatively safe and attractive, for probably the price will never be any lower than at present.

Ref.—Haw. Exp. Sta. Annual Report 1905:41; 1906:19; 1907:41. "Koamalu" by Ethel Damon (1931), Vol. I, pp. 181-2, 331-2. Thrum's Annual 1911:67-71. Planters Monthly III, 664 (1885); XV, 52 (1896).

**SILVER BEARDGRASS** Silver beardgrass (*Andropogon saccharoides*) is of very minor importance as a range grass, except in dry localities, where it may be valuable.

Ref.—Haw. Exp. Sta. Bul. 65:6, 1933.

**SISAL** Sisal, or sisal hemp, is the fiber of the long, tough, spear-pointed leaves of a century plant (*Agave sisalana*), which has for many years been cultivated very extensively in Mexico. In the middle of the nineteenth century sisal production was urged by some as an especially promising industry for Hawaii<sup>8</sup> but the sugar industry was claiming major attention just then and, moreover, Mexico was trying to maintain a monopoly on sisal by preventing the exportation of any live planting material.

<sup>8</sup>Trans. Royal Haw'n Agr. Soc. 1851, p. 27.

Although this was an obstacle to the introduction of the sisal plant into these Islands, interest in it as a potential crop grew stronger. The slump in the sugar market in the 1880's and the rising tide of beet sugar production in California accentuated the need of diversifying agriculture here, and sisal was frequently mentioned as being particularly promising for this purpose. Even the official organ of the Hawaiian sugar industry, the *Planters Monthly*, joined this chorus, declaring editorially<sup>9</sup> that "it will not do for us to sit down with our hands folded and wait till the California beet sugar scheme effectually cuts our throats"; sisal was recommended as a crop that ought to be established to support Hawaii if sugar should fail.

The strength of this movement was sufficient to bring about the successful introduction of this Mexican plant in 1893. At once thereafter there began to develop a small industry, at first on an experimental scale and later of commercial dimensions. The prospects seemed excellent because of the fact that this plant was well suited to land areas where rainfall was insufficient for sugar cane, and of this type of land there were many thousands of acres. Added to the impulse that came from fear of the beet sugar industry in California, there suddenly appeared a new impetus in the early 1900's when the leafhopper began to threaten the existence of the sugar cane industry. The possibility of substituting sisal for sugar cane in some of the drier areas was especially appealing at that time because of the high price of sisal fiber. This fiber was being imported in very large quantities from Mexico for use as binder twine in the large wheat areas of the United States. In 1900, for example, these imports amounted to 80,000 tons, worth nearly \$12,000,000, and Hawaiian agriculturists believed they could capture a good part, if not all, of that business. The price of 10 cents per pound, then prevailing, left a comfortable margin of profit above costs of production, and experience showed that a good quality of fiber could be grown and extracted here.

The first large plantation, the Hawaiian Fibre Co., with about 1000 acres, was established on Oahu in 1900 and 1901 by Wm. Weinrich, and several others later on other islands: 450 acres at Pahala, Hawaii, in 1902; 500

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<sup>9</sup>Vol. VI, p. 390 (1887).



acres at Kailua, Hawaii; smaller plantings on Maui and Molokai.

Thus begun, commercial production of sisal fiber made good progress for several years and the new industry seemed to have excellent prospects for the future. The following table of figures shows the extent of this development as reflected in the value of annual shipments to the mainland:

<i>Year</i>	<i>Value</i>	<i>Year</i>	<i>Value</i>
1903 .....	\$ 8,096	1918 .....	\$127,987
1905 .....	10,631	1919 .....	233,211
1910 .....	11,790	1920 .....	97,010
1911 .....	15,161	1921 .....	16,620
1912 .....	34,735	1922 .....	3,197
1913 .....	44,221	1923 .....	1,800
1914 .....	59,915	1924 .....	1,637
1915 .....	52,608	1925 .....	5,513
1916 .....	68,764	1926 .....	4,526
1917 .....	89,543		

This interest in sisal was short-lived, however, because of several factors: (1) The sugar cane leafhopper was brought under control and when its threat to the industry was thus removed the necessity of finding a substitute for sugar was less urgent; (2) the new pineapple industry was growing and expanding rapidly and could use the lands occupied by sisal and, furthermore, could afford to pay a higher rental for them; (3) the world-wide boom in sisal which began in 1900 came to an end in 1910, when so much fiber was coming into the market that the price fell considerably below the average cost of production. Only in Yucatan (Mexico) and German East Africa has the industry persisted to the present, for in both those places the wage scale is so low that it is not much of a factor.

Writing in the Advertiser (July 23, 1925), Jared Smith said that the demand had fallen off greatly in recent years because of the advent of new grain harvesting methods and also because of the use of steel cables by modern ships instead of ropes. "About the only remaining market for sisal," said Smith, "is for hula skirts, and now even that is gone, for they are being made of cellophane."

Ref.—Haw. Exp. Sta. Bul. 4 (1903); Annual Reports 1902:314; 1903:403; 1912:58; Thrum's Annual 1904:29; 1908:138-141. Haw. For. Agr. 1904:226-242 (Comprehensive article by L. G. Blackman); 1918:42-48 (McCaughy).

**SORGHUM** Sorghum, known also by many other names, including milo maize, kafir corn, Egyptian corn and feterita, is not grown in Hawaii as extensively as in temperate zone regions, although moderately good results have been obtained here. It is usually grown for use as green fodder and is cut before full maturity is reached, to avoid coarseness of stems. The yield is not as good as sudan or elephant grass.

Ref.—Haw. Expt. Sta. Annual Report 1913:38; 1914:37; 1915:41; 1916:29; U. H. Agr. Dept. Annual Report 1918:10; 1919:10; 1920:14; 1922:11; 1923:11; 1927:32. Planters Monthly XI, 98, 105; XIII, 238; XV, 27.

**SOUR SOP** The sour sop (*Annona muricata*) is a tropical fruit closely related to the cherimoya and not infrequently encountered in home gardens. The juice of its fruit is sometimes pressed out of the very fibrous pulp and used in blending with other juices in punch or ice cream.

There is no considerable commercial planting of this fruit.

See also "Cherimoya."

Ref.—Haw. Exp. Sta. Bul. 77:77-78 (recipes, uses, etc.).

**SOYBEAN** The soybean (*Glycine hispida*) is indigenous in Asia, where it is cultivated very extensively and used in many ways: the beans are cooked and eaten; also sprouted, and eaten as greens; oil is extracted, also soyo sauce; bean cake, bean curds, soybean meal and other products are manufactured from the beans; in the United States this bean is the basis of several new industrial products, as automobile steering wheels and other parts. Altogether, the soybean is probably the most useful member of the large leguminous family.

Most varieties of the soybean are adapted to temperate zone conditions and do not thrive well in Hawaii. A few varieties, however, have been grown successfully here on a small scale and are believed by Krauss<sup>10</sup> and others to offer exceptionally good promise of becoming a crop of major importance for this Territory. According to Dr. Krauss, "The crop is adaptable over a wide range of soil types and locations, for intercropping and for rotation

<sup>10</sup>F. G. Krauss in "Extension Letter," a mimeographed serial of the University of Hawaii, Vol. XV, No. 11, pp. 2-3, Nov. 1935.

with other crops, notably to follow the early potato crops immediately after harvest. Soybeans require the minimum of tillage and fertilization when following potatoes, etc., and produce a maximum yield under favorable season for harvest. They contain high food value for man and beast with a low cost of production.

"Among the outstanding varieties thus far tested by the Experiment Station and by the Agricultural Extension Service as well as in general field culture is the Biloxi, introduced to Hawaii from Mississippi in 1918. It has been demonstrated that the spring plantings almost invariably give the best results in yield and quality of product. Yields of seed have ranged from 800 pounds to 2000 pounds per acre for the average 100 to 120 day varieties. Cured forage yields have ranged from 1 to 4 tons per acre. There seems to be no good reason why one ton of prime seed per acre should not be produced when suitable varieties are planted on good land, on land which has produced 100 sacks of potatoes in an early spring harvest. One or two double disc harrowings of such potato land should put it into good shape for planting the soybean crop which is to follow. Little or no fertilizer other than the residue from the potato crop should be required. Under such conditions the crop should readily be produced at a cost not to exceed \$50.00 per acre. Of course, mechanical planting, harvesting, and threshing would need to be resorted to and the planting carried on on a large scale.

"Crops grown thus economically should prove fairly profitable, netting in the neighborhood of \$50.00 profit per acre. If carried on extensively, on a scale of not less than 2500 acres, an oil-expressing plant might be justified.

"Two methods for extracting oil are employed by American mills, termed the hydraulic and expeller processes. An average of 32 gallons (about 7.5 lbs. per gallon) of oil and 1600 pounds of oil cake is recovered from a ton of beans by the latter process. The 130 pounds unaccounted for represents loss due to natural waste and the evaporation of moisture. The cost of producing oil and cake is less with soybeans than with cotton seed. Cotton oil mills can readily be adjusted to handle soybeans, peanuts, and other oil-bearing seeds. The cost of equip-

ment to handle 2500 tons of beans would not exceed \$18,000 and should pay for itself in two or three seasons under good management.

"The soybean oil cake meal ranges from \$35.00 upwards per ton, while the price of the oil, which is competitive with and can be substituted wholly or in part for cotton seed, coconut and linseed oils, ranges from 5 to 10 cents per pound. In other words, a ton of soybeans when manufactured into oil and cake will bring around \$50.00 per ton. This would make a very low acre income for the beans, but would provide an outlet for surplus production.

"The composition of soybean oil cake meal will run around 44.0 per cent protein, 8.7 per cent fat, 27.0 per cent nitrogen free extract, and 6.0 per cent fiber. On this basis of high feeding value, especially in nitrogenous matter, the price quoted is very low and would enable its extensive feeding, especially when supplemented with large quantities of molasses and roughage or pasturage when fed to dairy cows, beef cattle, swine, and even poultry, including turkeys. Whole and ground soybeans are too rich in oil to be fed to livestock in large quantities, especially swine, in which case it produces soft pork.

"Soybeans are likewise a valuable food for man. They may be used in the same manner as dried kidney or navy beans, or as manufactured products such as tofu, miso, and soy sauce so extensively used by Orientals. The Journal of the American Medical Association recently stated editorially: 'The studies of Chang and Tso at Peiping University have stimulated interest in the soybean for infant feeding. So-called soybean milk gave results comparable to that of cow's milk and breast feeding. Chemists have learned how to turn soybeans into printer's ink, glycerin, celluloid, waterproof glue, soap and rubber substitutes and have listed 65 other products. The list grows larger every year.' "

Although the soybean was practically unknown in American agriculture twenty-five years ago, it is now one of the major crops of the country. In 1924 the acreage of soybeans raised in the United States was about 2,000,000 and in 1935 it had increased to 5,000,000 acres.

This crop offers attractive possibilities for Hawaii, to

occupy some lands not suitable for sugar cane or pine-apples, and should be carefully considered in any plan for diversification. For data on yields in Hawaii see Haw. Expt. Sta. Annual Report 1936, p. 20.

**SPANISH CHERRY** See "Brazilian Plum."

**SPINACH** Common spinach (*Spinacia oleracea*), although consumed in large quantities in Hawaii, is not produced extensively here. It is a cool weather plant and can be grown successfully in the truck gardens near Honolulu only in the winter and spring months. A recent crop survey (1936) showed only about 10 acres of spinach planted. Import records indicate that some 15,000 to 20,000 pounds per year are brought in from the mainland in the fresh state, but larger quantities come in canned. It is probable that total consumption here is between 100,000 and 200,000 pounds per year, with perhaps one-fourth of it supplied by local producers.

Krauss<sup>11</sup> calls attention to a New Zealand variety of spinach which thrives in our lowland areas at all times of the year, producing an excellent quality of foliage which should be capable of supplying all local consumption needs.

See also "Truck Crops."

**SQUASH** The squash and pumpkin are related to the melons and cucumber and have been cultivated in Hawaii for a great many years. During the gold rush days in California there were shipments of considerable size from these Islands; in 1851, for instance, some 51,769 squashes were sent.

The accidental introduction of the melon fly early in the present century proved to be a serious handicap to the production of squashes and pumpkins, for they seemed particularly susceptible to its attacks. In recent years, however, as this pest has been brought under partial control by parasites, this crop has begun to come back into more prominence, with about 200 acres devoted to various kinds of pumpkins and squashes.

The summer squash is still very difficult to produce

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<sup>11</sup>Agr. Ext. Bul. 16, pp. 123-125, 1932.

here because of the ravages of the melon fly and most of the consumption demand is filled by importations from California, which run to about 100,000 pounds per year.

There are several related plants which produce fruits quite the equal of summer squash for succulence and flavor and could be used here in place of the imported article, such as the chayote and the Chinese melon.

Ref.—U. H. Agr. Ext. Bul. 16:79, 1932.

**STAR APPLE** The star apple (*Chrysophyllum cainito*) is a tropical fruit common in the West Indies and Mexico. The fruit derives its name from the fact that the core in transverse section is somewhat star-like in shape. When thoroughly ripe the star apple is edible, but until then it is as astringent as an immature persimmon.

Introduced into Hawaii many years ago the star apple has become moderately common in gardens as an ornamental, but is seldom cultivated for its fruits which are eaten by very few people in these Islands. As a source of juice for blending with other kinds of fruit juices for punch or ice cream it may have some value worth exploiting.

**STARCH** Starch is extracted from many different kinds of plants, the world over, each kind yielding starch with certain more or less distinct characteristics. In chemical constituents starch is essentially the same, regardless of its source. In physical characteristics there are marked differences as to size and shape of the starch granule, in viscosity and other characteristics; some kinds seem to be more easily digestible than others in the human body, and some have physical qualities that make them particularly valuable for certain industrial uses, such as the manufacture of adhesives and the sizing of cloth and paper.

The three chief commercial sources of starch are corn, the Irish potato and cassava. Several millions of tons are manufactured every year in various countries from these three sources, and the product finds its way into consumption in many different ways, partly as food but much of it is used in the textile industries and other manufacturing enterprises. Neither corn starch nor potato starch, how-

ever, is suitable for certain purposes and other starch sources have been sought out to supply the need. For instance, for the making of the adhesive material for the back of postage stamps, envelope flaps, binding tape and so forth a type of starch is necessary from which dextrin of the proper consistency can be made. American manufacturers of this special adhesive have always depended upon imported cassava starch as their raw material, but recent experiments by the U.S. Department of Agriculture indicate that the sweet potato yields a starch which is just as good for this special purpose as cassava starch. "Sweet potato-starch dextrin," says the 1935 yearbook of the U. S. Department of Agriculture (p. 308), "is the first domestic product which has met the requirements of the Bureau of Engraving and Printing for this purpose." It is said, also, that this starch has been found to be satisfactory for the sizing of warp yarn and finishing, in cotton mills.

Another specialized demand for starch of a particular texture is in the making of foods for convalescents and infants. Arrowroot starch is considered satisfactory for this, as are, also, several others, including taro starch.

The following statistical figures compiled by J. C. Riperton<sup>12</sup> indicate the relative degrees of importance of certain starches in American consumption.

(a) *Production, Importation, and Prices in the United States*<sup>13</sup>

(Data are the Average of the Six-Year Period, 1929 to 1934, incl.)

Source of Starch	Total Production Tons	Total Imports Tons	Price (duty paid) per ton
Corn .....	464,670	None	\$ 68.00
Potato (White).....	6,570	8,348	85.00
Cassava (Tapioca).....	None	73,763	40.00
Arrowroot .....	None	992	124.00
Sago .....	None	4,448	29.00
Rice .....	None	517	76.00
Wheat.....	20,050	15	74.00

<sup>12</sup>Of the Hawaii Agricultural Experiment Station.

<sup>13</sup>From data furnished by Bur. Agr. Economics, U. S. D. A. and U. S. Dept. of Commerce.

(b) *Starch Imports Into United States, Six Years*<sup>14</sup>

	(Casava)		(Potato)		(Arrowroot)	
	Imports Tons	Value per ton	Imports Tons	Value per ton (duty paid)	Imports Tons	Value per ton
1929 .....	79,784	\$52.00	14,141	\$84.00	489	\$140.00
1930 .....	50,468	60.00	7,970	86.00	494	126.00
1931 .....	70,477	42.00	9,152	87.00	987	120.00
1932 .....	61,744	30.00	5,371	84.00	954	120.00
1933 .....	94,150	30.00	6,640	86.00	1,288	122.00
1934 .....	85,950	34.00	6,810	.....	1,742	126.00

(c) *Chief Starch-Producing Nations of the World*

*Corn starch:* United States—Exports 75,000 to 200,000 tons per year.

*Potato starch:* Germany—Exports 110,000 tons per year.

*Cassava starch:* Dutch East Indies—Exports 105,000 tons per year.

(d) *Chief Uses of Starch*

*Corn starch:*

Grocers (Package starch for retail trade).....	23%
Textiles (Cotton mills and textile finishers).....	18%
Dextrins, pastes, gums.....	16%
Bakers, confectioners .....	8%
Baking powder .....	7%
Brewers .....	5%
All others .....	23%

*Potato starch:* Largely textile finishing, pastes, gums.

*Cassava starch:* Better grades for food (tapioca) and dextrins. Cheap grades for wood glues.

(e) *Present Tariff on Starches (Tariff Act of 1930)*

Potato.....	2.5¢ per lb.
Corn	} .....
Wheat	
Rice	
Cassava	} .....
Sago	
Arrowroot	
	No duty. <sup>15</sup>

Hawaii has been so busy producing sugar that her latent potentialities in the manufacture of starch have gone undeveloped. Small beginnings, however, have been made along several lines which are of some importance in our present study of diversification possibilities for this Territory.

<sup>14</sup>From data furnished by Bur. Agr. Economics, U. S. D. A. and U. S. Dept. of Commerce.

<sup>15</sup>These starches come into the United States as "flour," and thus escape the duty levied on foreign starches.



*Tree Fern Starch*—The first of these, in point of time, was the discovery several centuries ago by the early Hawaiians that a good food starch could be extracted from the trunks of tree ferns. This, however, was never exploited to any great extent until recent years. In 1920 the Hawaii Experiment Station undertook to study the nature of this starch and to investigate the commercial possibilities in its manufacture, for there are great forests of tree ferns in various parts of the Territory. The conclusion finally reached was that as a commercial source of starch the tree fern does not seem very promising, because of the slow rate of growth of the trees; accordingly, the investigations were dropped after a few years.

*Taro*—Taro, for many centuries the staff of life for the Hawaiian people, has been used on a small commercial scale as the source of a starch or flour which is said to be especially valuable as a food for convalescents and infants. This starch or flour has made its appearance in the market under two different names, "taroina" and "taromano," representing two distinct attempts to commercialize the idea of making taro starch. Neither of them made much of a success and this source of starch remains largely undeveloped, unless one considers poi as a starch development.

A portion of the AAA sugar processing tax fund is being devoted to a study of taro production; and one feature of this study is an experimental effort to transform taro into a dry powder or flour. This is different in some respects from both taroina and taromano, and its commercial possibilities seem attractive. As a source of pure starch, taro would not be able to compete successfully with certain other crops, because of the greater expense of production. The chance of commercial success for a taro product outside of Hawaii depends upon the possibility of establishing for itself a reputation as a food of special value.

*Cassava*—Cassava starch, sometimes called "tapioca," is well known in the world markets, both for its value as a food and for certain industrial uses, also. The American market consumes about 80,000 tons per year, imported from various tropical regions, chiefly the Dutch East

Indies. The cassava plant grows well in Hawaii and yields heavily, five tons of roots per acre being obtained in more or less typical cases, with 10 to even 18 tons not unknown. Grove Farm, on Kauai, has experimented in the extraction of the starch with satisfactory results so far as quality of the product is concerned. W. H. Rice, also, operated a cassava starch mill at Kipu, Kauai. The cost of manufacture, however, is considerably more than the prevailing market price. It would appear that in competition with other tropical countries Hawaii would experience much difficulty in making a commercial success of cassava starch production, because of higher wages and high land rentals here. For it must be kept in mind that, although there is a duty on foreign cassava starch, it comes into the United States under the name of cassava "flour" and thereby eludes the tariff. But for this, there might be developed at least a small industry in the production of this starch.

*Canna*—Edible canna, the source of so-called "Queensland Arrowroot" starch, was introduced into Hawaii about 1898. In 1916 the Hawaii Experiment Station began some investigations of the possibilities of establishing a canna starch industry here, for the plant flourishes well under Hawaiian conditions and characteristically yields heavy crops of tuberous roots, the source of the starch. These investigations led to the establishment of an incipient industry in 1922 in the Waimea section of Hawaii. A corporation was formed and a small factory was built which turned out several tons of good starch. Mechanical difficulties in connection with the extraction machinery were encountered. This and some financial troubles caused the cessation of their efforts and the dissolution of the company.

In 1930 the Honolulu Chamber of Commerce made a study of the situation, with cooperation from the Los Angeles Chamber of Commerce. Stein-Hall and Co., of New York, one of the largest starch importers in the United States, after giving careful attention to the possibilities of producing canna starch here, declared that the local product was "the finest they had ever seen."<sup>16</sup> The

<sup>16</sup>Quoting from a report by John A. Hamilton, Secretary of the Honolulu Chamber of Commerce, April 14, 1930.

New York firm offered to contribute generously to the capitalization of a new company to develop this industry, but local capital was unwilling to take up the offer, for the recent failure at Waimea was too strong a deterrent.

Later, when the sugar industry was put on a quota basis by the federal AAA, some consideration was given to the possibility of developing canna starch production on idle sugar lands. A new study of market possibilities was not very encouraging, however, for it indicated that the demand for this type of starch was not very great: about 10,000 tons per year, at 5 cents per pound; at lower prices it might displace some potato starch and have a larger market, but it was doubtful if production costs could be reduced below the 4 cents per pound level. This was not considered a large enough market to meet the readjustment needs of the dislocated sugar industry, and attention turned to other crops.

*Sweet Potato*—While the market demand may not be large enough to warrant the sugar plantations developing the canna starch industry, it is sufficient to provide a good outlet for a minor industry independent of sugar plantations. Probably better, however, would be the idea of producing sweet potato starch, for recent investigations by the federal government indicate that this starch is excellent for the same uses for which canna starch would be used, and in addition the sweet potato crop would be more widely useful than canna roots for livestock feed, human food, etc.

With excellent yields of sweet potatoes here, this crop might offer some possibilities worth investigation. A combination of a canning industry, with starch manufacture to utilize the culls and surpluses, might be sufficiently profitable to use certain marginal or submarginal sugar lands to good advantage. As a form of insurance against possible emergencies in food shortage, this crop would be very useful for feeding our population.

*Arrowroot*—The old Hawaiian arrowroot (*pia*), made from *Tacca pinnatifida*, offers some interesting possibilities for commercial development. See "Arrowroot."

Ref.—Several bulletins published by the Hawaii Experiment Station are of special value: No. 53, "Hawaiian Tree Fern Starch," 1924; No.

54, "Edible Canna in Hawaii," 1924; No. 57, "Edible Canna in Waimea," 1928; 63, "Physico-chemical Properties of Edible Canna and Potato Starches," 1931; 70, "The Manufacture of Poi from Taro in Hawaii," 1933. Also, the following references in Haw. Exp. Sta. Annual Reports: 1902:322; 1905:23; 1916:24, 25; 1917:51; 1918:48; 1919:41, 45; 1920:27; 1921:26, 38; 1922:8, 17; 1923:9; 1924:11, 12, 14; 1925:11; 1926:12, 15; 1927:13, 15; 1928:14, 19; 1930:13; U. S. D. A. Yearbook 1935:308-9.

**STARFRUIT** See "Carambola."

**ST. JOHN'S BREAD** See "Carob."

**STRAWBERRY** Strawberry (*Fragaria chiloensis*) culture is a small industry in Hawaii, with perhaps a total of thirty acres devoted to it, chiefly on Oahu. The cooler lands of the Wahiawa district seem to offer the best conditions for this crop. The Hawaiian product is smaller than that of the mainland states and less attractive.

It is not known when the strawberry was first introduced into Hawaii, but it was probably during the nineteenth century. The Hawaii Experiment Station gave it some attention in 1920 for the first time.

Ref.—Haw. Exp. Sta. Bul. 77:79 (recipes); Annual Report 1920:21; 1922:6.

**STRING BEAN** The pods of several species<sup>17</sup> of beans are used for food in the immature stage after being cooked, either whole or cut into short pieces. The more common of these are known to the trade as "string beans," but by gardeners are sometimes known by special names such as "wax beans," "snap beans," etc. Taken collectively, these are cultivated more extensively in Hawaii than any other type of bean, the present acreage being between 100 and 150 acres for all the islands combined; the largest part of this is, of course, on Oahu, in the truck gardens which supply Honolulu.

There are some possibilities of developing a seasonal (winter) trade in the shipment of string beans to the mainland, provided a means can be found of treating the product so that the danger of disseminating the melon fly will be removed. At present the string bean is on the quarantine list.

<sup>17</sup>See also "Goa Bean," "Chinese Pea" and "Yard-long Bean."

See also "Beans" and "Truck Crops."

Ref.—U. H. Agr. Ext. Bul. 16:61, 1932.

**STRYCHNINE** The well-known poisonous drug, strychnine, is obtained from the seeds of a tree (*Strychnos nux-vomica*) which grows well in Hawaii. No effort has been made, however, to exploit the plant here, commercially.

**SUDAN GRASS** Sudan grass (*Holcus sorghum sudanensis*) is cultivated very extensively in Hawaii, especially for use as fodder in dairies, but not infrequently for pasturage, as well. It thrives best at the lower elevations but will grow at relatively high altitudes. It is a tall grass, 3 to 7 feet high, and is relished by cattle and horses. When cut for fodder, the new growth springs up very quickly, making it possible to take several cuttings in a year. After about a year, it becomes necessary to replant to obtain maximum yields. When pastured, the field must be rested at frequent intervals to protect it against being trampled out.

Sudan grass is probably the best of all green fodder crops in Hawaii, yielding 40 to 50 tons per year, and being valuable for mixing with other feeds. Its only drawback is the necessity of replanting every year.

Ref.—Haw. Exp. Sta. Bul. 65:47, 1933. Also, U. H. Agr. Dept. Annual Reports 1918:11; 1919:11; 1920:13; 1921:18; 1922:10; 1925:8, 45; 1928:35.

**SUGAR CANE**<sup>18</sup> Sugar cane (*Saccharum officinarum*), while not indigenous in Hawaii, has been here for many centuries, having been brought in probably by the early Polynesian immigrants. Its original discovery by man as a source of sugar was thousands of years ago, probably in India; from there the knowledge of it spread both east and west. Chinese writings dating back nearly 3000 years mention sugar cane as having been imported from India. Doubtless, in those early centuries, it was carried to the islands of the South Pacific and thence to Hawaii. At any rate, it was here when Captain Cook first visited this group of islands in 1778, for he noticed it

<sup>18</sup>This statement concerning sugar cane is largely a condensation from "The Story of Sugar in Hawaii," revised edition 1929, published by the Hawaiian Sugar Planters' Association.

growing in some of the gardens. It was not used by the Hawaiians as a source of sugar, however, for the art of sugar extraction seems not to have come with the plant when it was brought here.

The first effort to make practical use of the sugar cane plant here was in 1802. A Chinese who came to the Islands in 1802 on a vessel trading for sandalwood brought a stone mill and a boiler with him. He set up this apparatus on the island of Lanai, but after grinding one small crop he left the Islands. Don Francisco de Paula Marin, a Spaniard who came to Hawaii in 1791, succeeded in making sugar in 1819.

In 1823 an Italian named Lavinia made sugar in Honolulu by pounding the sugar cane with stone beaters, on poi boards, and boiling the juice in a small copper kettle.

In 1825 an Englishman, John Wilkinson, first began the cultivation of sugar on a large scale by planting 100 acres in Manoa Valley, Oahu; but after his death in 1827, the cultivation was discontinued.

In 1835 the sugar industry received its first permanent impulse from an American firm, Ladd & Company, which obtained a grant of land from the king and established a small plantation at Koloa, Kauai. With the gold rush to California in 1849 and the opening of the Civil War in 1861 the demand for Hawaiian sugar was stimulated and the industry first commenced to thrive, although maximum progress did not occur until a number of years later.

In 1875, a reciprocity treaty was negotiated between the United States and the Hawaiian Kingdom, allowing Hawaiian sugar into America free of duty. This treaty marks the real beginning of development. Twelve years after the signing of the treaty, the Islands exported over 100,000 tons of sugar. Since the annexation of Hawaii to the United States in 1898, continuous progress has been made in the development of the industry.

An evidence of this progress is the increase of sugar production from 277 tons in 1856 to over a million tons in 1932; the land area under sugar cane expanded from a few hundred acres in the 1850's to about 250,000 acres in the 1930's; capital investments, also, had increased very greatly in the same period from a few hundred thousand

to about \$175,000,000; similarly, wages paid by the industry amounted to nearly \$25,000,000 per year in the 1930's instead of the few thousands in the earliest years.

Eminent authorities who have made a study of the sugar industry throughout the world have declared that the scientific culture and manufacture of sugar is further advanced in the Territory of Hawaii than in any other part of the world.

It takes about eighteen months for a crop to mature in Hawaii. The plantation area is about double that used for any one crop. While one crop is being harvested another is growing. During certain periods each year, usually in June and July, a visitor on an Hawaiian plantation can see one crop growing, one being harvested and one being planted. Harvesting begins in November and usually ends in July or August, and planting begins from March to June and usually ends in September, according to plantation conditions.

The production of sugar per acre varies according to conditions and the type of cane. The amount of sugar obtained per acre of cane varies greatly, the poorest yields producing as low as two and one-half tons while some large individual fields produce as much as sixteen tons per acre;<sup>19</sup> the average, however, is six and one-half tons.

Hawaii's sugar lands are among the most intensely cultivated lands in the world. Year after year the sugar-growing lands of Hawaii have been made more productive through the study and use of scientific methods. Over forty years ago it was predicted that the soils of Hawaii would be rapidly exhausted. Science came to the front with methods that have given the sugar industry of Hawaii an unexampled record in agricultural history. Lands have produced constantly a yearly harvest without rest or fallow, and are now more productive than they were a generation ago.

These results are mainly due to the scientific use of fertilizer. The fertilizer bill of Hawaii's sugar industry for

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<sup>19</sup>It should be noted that this is not the *annual* production rate, for the crop requires from 16 to 22 months to mature.

1928 was close to \$5,600,000. This is double the amount used in 1914. Over 95,000 tons, or an average of over 1650 pounds of fertilizer per crop were applied to every acre of sugar cane, the largest amount used on any staple crop in the world. Sugar production in Hawaii has shown an average increase of two and three-quarters tons to the acre since 1905.

The Experiment Station of the Hawaiian Sugar Planters' Association has made an exhaustive study of Hawaiian soils. Extreme care is taken to protect the fertility of these soils and the highest quality of the proper elements are brought here from various parts of the world to be used in fertilization.

*H. S. P. A. Experiment Station*—Although it is usual for an agricultural industry to look to the government for scientific protection and development, the sugar industry in Hawaii has developed its own research station, staffing, equipping and maintaining it wholly at the expense of the producers. This station was established in 1895, with an initial staff of three scientists which subsequently has grown to over forty; the first year's expense was \$7000, but within thirty years it had increased to about \$500,000 per year.

One of the most notable of the achievements of this Station was the "creation" in 1905 of a new variety of sugar cane, H 109, which replaced the older Lahaina variety and saved the industry from the fate of virtual extinction which seemed in prospect because of the rapid failing of that variety. After several years of experimental plantings to test the new variety, it was generally adopted as the best producer of sugar and the acreage rapidly increased to nearly 100,000 within a decade or two. Meanwhile the search is being continued for even better varieties.

The work of the Station in overcoming several insect scourges was so remarkable as to be almost dramatic in its interest. There was, for example, the campaign against



the leafhopper, which was finally vanquished by parasites sought out in various parts of the world and brought here, in some cases with great difficulty. Later, there were other pests: the cane borer, the *Anomala* beetle, and others. Likewise, devastating diseases have had to be combated by the Station scientists.

*Irrigation*—For each ton of sugar produced, 2085 tons of irrigation water are used, or over 500,000 gallons.<sup>20</sup> At the average acreage production of six and one-half tons of sugar this means that each acre of land receives enough water to cover it to a depth of nineteen feet during one crop.

The irrigation systems on Hawaii's sugar plantations rank among the finest in the world. They are unequalled in any other sugar-growing country.

Mountains have been tunneled, hundreds of miles of canals and ditches have been built, siphons, flumes, reservoirs, as well as hundreds of artesian wells and scores of electric and steam-operated pumping stations are in use. Around \$40,000,000 has been spent by the plantations in irrigation equipment alone. The men back of these projects have been called the "most daring and successful pioneers of irrigation in the world."

The first large irrigation project in the Islands was undertaken on Maui by Samuel T. Alexander and Henry P. Baldwin. From the forest-covered slope of East Maui, cut by deep gorges and valleys, water was brought seventeen miles through ditches and siphons to the potentially fertile but dry leeward slopes. In spite of difficulties in construction and financing the project was completed in 1878 at a cost of \$80,000, a cost that would be ridiculously low today.

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<sup>20</sup>In laboratory experiments conducted by Prof. H. A. Wadsworth in which sugar cane plants were grown in tanks, with all water losses eliminated except transpiration through the leaves, sugar was produced at a cost of 493 tons of water per ton of sugar. This situation is never duplicated in the field, however, and the water cost is much higher. In some instances the ratio is about 1000 tons of water per ton of sugar, but the average is said by Prof. Wadsworth to be about 2000 tons of water per ton of sugar. In earlier years, with less efficiency in irrigation, the ratio was said to be about 4000 tons (about 1,000,000 gallons) of water per ton of sugar.

This was immediately followed by a larger ditch constructed by Claus Spreckels, to irrigate the land on the central Maui plain. Since that date a very extensive water system has been developed, paralleling and extending the lines of the original system, at a cost of over \$4,000,000. The latest addition to this great Maui project is the "Waialoa Ditch," which cost over \$1,500,000 and is capable of delivering 170 million gallons of water daily.

On Oahu, the great Waiahole Aqueduct, built by the Oahu Sugar Company at a cost of over \$2,500,000, brings water from the opposite side of the Koolau mountains through a tunnel nearly three miles long.

The Olokele ditch, supplying the Hawaiian Sugar Company's plantation on Kauai with water from the Olokele Canyon, is fourteen miles long and its upper portion includes a continuous tunnel for six miles, within a cliff. There are a number of other spectacular engineering achievements on the plantations, which have enabled thousands of acres of land to be placed under intensive cultivation, and have greatly increased the Territory's productiveness. Development of water is still going on, and a number of plantations now have large projects under construction.

Some plantations have developed pumping systems to draw from artesian water supplies instead of bringing in surface waters through long ditches and tunnels. One plantation, for example, has a pumping capacity of 120,000,000 gallons of water per day in addition to the amount it gets from its mountain supply. This one plantation pumps and uses daily nearly three times the water consumed by all the population and industries of the city of San Francisco, and one and one-half times the amount used by the city of Boston. There are a number of other plantations having from sixty to one hundred and ten million gallons pumping capacity per day.

Many of the plantations have from six to twelve or more pumping stations which tap the water supplies. Water is pumped from these stations to varying elevations, some-

times as high as seven hundred feet or more. These stations are equipped with large steam or Diesel or centrifugal pumps electrically driven. The plantations are watchful in keeping their pumping equipment up to date.

At some locations on the plantations pumps have been placed in shafts between 200 and 400 feet below the surface of the ground in order to reach the water level. Several of the large pumping stations are built in pits, giving the observer a thrill when he looks down upon their glistening array of machinery. Each pumping station taps a number of wells and a single unit may pump as much as 22,000,000 gallons of water per day.

At Ewa Plantation on Oahu, the irrigation water supply depends entirely upon sixty-one artesian wells and the pumping capacity is over 100,000,000 gallons per day.

The pumps are usually kept working day and night and the night water is deposited in a series of reservoirs built throughout the fields. The steep slope of the land and the nature of the soils on the Islands make the storage of surface water from streams in extensive reservoirs an extremely difficult, and in many cases, an impractical undertaking. The largest reservoir in the Territory is the Wahiawa Reservoir near Schofield Barracks. Here the whole valley was dammed up, creating a reservoir capacity of 2,544,000,000 gallons. The Koloa Reservoir on the island of Kauai covers a square mile of land and has a capacity of 2,225,000,000 gallons. The Alexander Dam on Kauai, also is worthy of note.

Extensive tests in irrigation have been made by the plantations and by their Experiment Station. The most effective and economical methods of applying the water to the sugar crop have been adopted. Experts in this work are constantly striving for the maximum results in this branch of the sugar industry.

*Cane Transport*—Sugar cane is carried from the fields to the mill in a variety of ways: by railroad trains, by flumes, or by overhead cable lines. Thirty-two plantations have extensive railway systems, with a total of about 900

miles of main-line track and 300 miles more of portable track; some 140 locomotives and other rolling stock worth \$5,000,000 run on these tracks to transport millions of tons of cane to the central mills.

Several plantations are so situated that they can flume their cane to the mill, using small streams diverted from their natural courses into many miles of wooden flumes. Others use overhead cable lines, with gravity to carry bundles of cane down from the fields.

*Builders of the Industry*—Many people have had a part in the building of this great industry. Thousands from Europe, mainland America, China, Japan, the Philippine Islands, and elsewhere have made their various contributions of physical strength, intellect and money to develop the extensive plantations, great mills and refineries and the transportation facilities which are essential parts of the industry.

The pioneers included men who brought capital to invest, and many others who came here poor, but worked their way up through sheer pluck and industry. Fortunes were lost as well as made. Many succeeded and many failed, but all contributed their share to development. There were energetic Americans, and many native Hawaiians high in the councils of their kingdom; Englishmen, Scotchmen, Irishmen, Norwegians, Germans, Portuguese, Spaniards—men of various nationalities, but men who possessed in common the pioneer spirit and energy. Many of them have contributed inventions which not only advanced the sugar industry here, but had a far-reaching effect on the sugar industry throughout the world.

Noteworthy among the pioneers were James Campbell from Ireland, Robert W. Wood from America, Valdemar Knudsen from Norway, H. P. Baldwin and S. T. Alexander, both born in Hawaii, Claus Spreckels and John M. Horner from California, Captain James Makee from Massachusetts, Paul Isenberg from Germany, W. H.

Rice, a son of Hawaii, Charles R. Bishop, B. F. Dillingham, and many others.

The Hawaiian Sugar Planters' Association, known popularly as the H. S. P. A., is perhaps one of the most unique business associations in the world. It is an unincorporated, voluntary association of thirty-seven plantation companies which have for years combined in working for the common good of the sugar industry of Hawaii, and indeed of the world.

The first attempt at cooperation by the plantations occurred in the early 1850's with the organization of the Royal Hawaiian Agricultural Society. This association went out of existence, however, in a business depression about 1857, and no further attempt was made until 1882. At a convention held in the rooms of the Chamber of Commerce in Honolulu in March, 1882, The Planters' Labor & Supply Company was formed, with leading plantations throughout the Islands as members. In 1895 this company was reorganized under its present name of the Hawaiian Sugar Planters' Association.

The purpose of the H. S. P. A. is to work for the benefit and development of the sugar industry of Hawaii. One of the most outstanding achievements of the Association is its Experiment Station, where scientific study and control of the industry have made possible great advancements and have accomplished and promoted work which has been of far-reaching benefit to the Territory in general.

The H. S. P. A. studies and compiles accurate records about the sugar industry, and constantly supplies valuable information and data to all its members. The securing of labor for all plantations that are members is also a very important service of the Association.

Hawaii's record in sugar production is set forth in the following table of figures. At present the sugar made in this Territory constitutes about 3.25 per cent of the total world production, including both cane and beet sugar.

## HAWAIIAN SUGAR PRODUCTION

(From Early Records Down to Date, in Tons of 2000 Pounds)

<i>Year</i>	<i>No. of Tons</i>	<i>Year</i>	<i>No. of Tons</i>
1837.....	212	1887.....	106,362
1838.....	44	1888.....	117,944
1839.....	50	1889.....	121,083
1840.....	180	1890.....	129,899
1841.....	30	1891.....	137,492
1842-1843.....	572	1892.....	131,308
1844.....	257	1893.....	165,411
1845.....	151	1894.....	153,342
1846.....	150	1895.....	147,627
1847.....	297	1896.....	221,828
1848.....	250	1897.....	251,126
1849.....	327	1898.....	229,414
1850.....	375	1899.....	282,807
1851.....	11	1900.....	289,544
1852.....	350	1901.....	360,038
1853.....	321	1902.....	355,611
1854.....	288	1903.....	457,991
1855.....	145	1904.....	367,475
1856.....	277	1905.....	426,428
1857.....	350	1906.....	429,213
1858.....	602	1907.....	440,017
1859.....	913	1908.....	521,123
1860.....	572	1909.....	535,156
1861.....	1,281	1910.....	518,127
1862.....	1,503	1911.....	566,821
1863.....	2,646	1912.....	595,258
1864.....	5,207	1913.....	546,798
1865.....	7,659	1914.....	617,038
1866.....	8,865	1915.....	646,445
1867.....	8,564	1916.....	593,483
1868.....	9,106	1917.....	644,574
1869.....	9,151	1918.....	576,842
1870.....	9,392	1919.....	603,583
1871.....	10,880	1920.....	556,871
1872.....	8,498	1921.....	539,196
1873.....	11,565	1922.....	609,077
1874.....	12,283	1923.....	545,606
1875.....	12,540	1924.....	701,433
1876.....	13,036	1925.....	776,072
1877.....	12,788	1926.....	787,246
1878.....	19,215	1927.....	811,333
1879.....	24,510	1928.....	904,040
1880.....	31,792	1929.....	913,670
1881.....	46,895	1930.....	924,463
1882.....	57,088	1931.....	999,787
1883.....	57,053	1932.....	1,025,354
1884.....	71,327	1933.....	1,035,548
1885.....	85,695	1934.....	936,318
1886.....	108,112	1935.....	963,316

<sup>21</sup>First Record of Exportation.

*By-Products*—Several by-products of the sugar industry in Hawaii are of considerable importance, notably stock feeds, alcohol, paper, wall board, cellulose, fertilizer, and other articles; others have been sought, as wax. For details, see "Alcohol," "Bagasse," "Molasses," "Wax," etc.

The cane tops are to some extent used as fodder for plantation animals and dairy cows.

See also "Feeds for Livestock."

**SUMACH** See "Tan Bark."

**SUNFLOWER** A giant type of sunflower (*Helianthus*) is cultivated in some countries for the seeds which are used as feed for poultry and other livestock. Several trial plantings in Hawaii have not given encouraging results and it is doubtful if this plant offers any attractive possibilities for extensive production here. Birds do a great deal of damage to the crop. The yields obtained were about 2500 pounds of dry seeds per acre.

See also "Jerusalem Artichoke."

Ref.—U. H. Agr. Dept. Annual Report 1920:14; 1927:33.

**SUNN HEMP** Sunn hemp (*Crotalaria juncea*), a leguminous plant, is a good source of fiber.<sup>22</sup> Although no thorough test of it has been made in Hawaii, Dr. Krauss considers it one of the most promising for fiber purposes and is responsible for the following statement concerning it.

Sunn hemp in India is sown annually at the beginning of the rainy season in early spring and harvested at the end of September or the beginning of October. This is also the most favorable season for planting in Hawaii, although the crop can be grown through the winter months and harvested or turned under in the spring so that the land may be utilized for other crops, such as sweet potatoes, corn, field beans, etc., during the summer months. Sunn hemp would probably rotate very satisfactorily with the early export potato crop. A double disc harrowing of a newly harvested potato field would be all the tillage needed, while the residual fertilizer remaining from the

<sup>22</sup>It is also valuable as a green manure crop, for in sixty days it makes a lush growth which may be plowed under to improve tilth. See Haw. Exp. Sta. Annual Report 1924:12; also, an article by O. C. Magistad et al in Journ. American Soc. Agronomy, Vol. 26, No. 5, pp. 372-380, May, 1934.

potato crop would, in most cases, supply all the fertility needed by the succeeding sunn hemp crop. Almost any crop following the sunn hemp would be benefited, because of its ability to extract large amounts of free nitrogen from the air, and at least part of this would be returned to the soil in turning under the plant stubble. The crop grows well on a great variety of soils, from sea level to an altitude of at least 3,000 feet. Lighter and not too rich soils would probably be found most suitable for the best fiber. When grown as a catch crop for green manuring<sup>23</sup> and for suppressing weeds, it is best to sow the seed thickly broadcast up to 80 pounds per acre. The seed for fiber might best be drilled in rows with a grain drill, spacing the drills 12, 18, or 24 inches apart, depending on circumstances. Twenty to forty pounds of seed will be required per acre when drilled as indicated. The closer the plants stand, the straighter they will grow, and if used for fiber they will be freer from detrimental lateral branches. The plant grows from four to eight feet in height, depending on spacing, soil fertility, and moisture supply. The yields in a green crop range from 10 to 20 tons per acre. The growing season ranges from about 120 to 160 days, dependent on location, season, and cultural practice.

In Hawaii the crop has been singularly free from disease and attack from insect pests. Like most legumes, this crop responds to phosphatic fertilizers, especially in the higher lands, which are often deficient in this element.

The fiber of sunn hemp is prepared by doubling up the bundles of dried stems and placing them, weighted down, in pools of water, completely submerging the mass as is done in retting jute and like material. Retting requires four to five days during the warmer seasons of the year and possibly twice as long in the cooler seasons of the year. Fresh, moving water is said to be preferable to stagnant water for retting, because the color and luster of the fiber are influenced thereby; on the other hand, stagnant water is conducive to hastening the retting process.

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<sup>23</sup>The H.S.P.A. Experiment Station has used this plant, as well as other legumes, for green manuring purposes. See *Planters Record* V, pp. 210, 345 and VII, p. 363.



The process of stripping and washing the fiber consists of beating the stems to separate the various tissue layers. The resulting hank of cleaned fiber is then wrung out to remove the excess water, and is twisted and hung for drying and bleaching. It is then plaited threefold into a "tail" and in that form it is sold for manufacture into burlap.

Ref.—Planters Monthly Vol. VI, pp. 454-457 (1887).

**SURINAM CHERRY** The Surinam cherry (*Eugenia uniflora*), also called French cherry, or Cayenne berry, is an attractive shrub used in moderate abundance as an ornamental throughout Hawaii, notwithstanding the fact that it is only a recent introduction. Its bright-colored oddly ribbed fruits make it a striking feature in any garden. The fruit is very tart and has an agreeable bitterness which makes it popular for use in jelly and jam. This, however, is not developed on a commercial basis and there is practically no production of this fruit outside of household gardens and estates. It would seem to offer some possibilities for large scale cultivation.

Ref.—Haw. Exp. Sta. Bul. 77:80-82 (recipes, uses, etc.).

**SWAMP CABBAGE** Swamp cabbage (*Ipomoea reptans*) is not in any way related to the head cabbage, as it belongs to the sweet potato family. It is a creeping vine which grows in swampy areas and produces foliage which is somewhat succulent and good to eat when cooked as greens. It is an Asiatic plant, believed to have been introduced here by early Chinese immigrants.<sup>24</sup> Its consumption is very limited.

**SWEET CLOVER** Sweet clover (*Melilotus alba*) is a temperate zone perennial plant very useful for pasturage. It does not thrive well in Hawaii, judging from trials at the University Farm.

Ref.—U. H. Agr. Dept. Annual Report 1919:12; 1920:14.

**SWEET POTATO** The sweet potato (*Ipomoea batatas*) has been under cultivation in Hawaii for many centuries. It is believed to have been brought here about 500 A.D. by the first Polynesian immigrants, the pro-

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<sup>24</sup>Haw. Exp. Sta. Bul. 60, p. 24, 1929.

genitors of the present Hawaiians, for the sweet potato and taro have been the two chief staple foods of this people for a very long time. Captain Cook on his discovery voyage reported finding very large sweet potatoes produced here. Other reports of those ancient times indicate that the Hawaiians had developed considerable skill in the cultivation of this crop, apparently having discovered that the propagation of only the most productive plants gives the best results at harvest time.

Cultivation of this crop continued extensively after the coming of the white people, but gradually diminished as the Hawaiian population decreased in numbers. A temporary upward turn came during the years when many whaling ships were calling here for food supplies; in the gold rush days some shipments of sweet potatoes were sent to California, which still further influenced the revival of interest in this crop in the middle of last century. In the latter part, however, production declined again to a relatively low point and remained there until the World War stirred up a new interest in this food commodity. Meanwhile, however, the Hawaii Experiment Station, in the same year it was established (1901), began to direct attention to the possibilities of making sweet potato production an industry of at least minor importance, pointing out that imports of California sweet potatoes were larger in volume than the local production and commanded a higher price because of better grading, in spite of the fact that it is a sub-tropical plant and should thrive better in Hawaii. In 1910 a further effort was made by the Station to arouse interest in this crop, this time by making some trial shipments to California to test the possibilities of developing a winter and spring trade with the mainland when production there was impossible. Nothing of commercial importance came of it, however, and the situation continued about as it had been. A few years later another obstacle arose in the form of a federal quarantine against sweet potato shipments to the mainland, imposed because of certain insect pests attacking the tuber and stem of the plant.

When the World War began to affect Hawaii in 1917 by threatening to cut off normal food shipments, the sweet potato loomed into importance as a possible substitute

for certain imported articles. It was planted in many home and school gardens, and some 350 acres of agricultural lands were devoted to this crop. Overproduction resulted, causing some unfavorable reactions, but in spite of this a considerable interest has continued, to the present.

The Hawaii Experiment Station began in 1917 to develop superior types by cross-breeding and selection, and at times had a very large number of varieties growing under test. Interestingly enough, they found the old varieties formerly grown by the ancient Hawaiians quite equal and in some instances superior to the newer varieties introduced from the mainland. By 1924 the Station had succeeded in developing several particularly good strains, one, for instance, yielding at the rate of 23 tons of potatoes per acre,<sup>25</sup> while the usual harvest was 7 to 10 tons; Krauss had obtained yields on his Maui farm as high as 17 tons.

The sweet potato offers some interesting possibilities for greater exploitation in Hawaii, not, however, as an export crop in the fresh state, because of quarantine restrictions against it. These possibilities are three: (1) As a feed for livestock it has certain values which could be capitalized for a partial replacement of imported concentrates, thus reducing a little the cost of dairy products and pork; feeding tests show that 3 pounds of sweet potato roots have a feed value about equal to one pound of beet pulp; in addition to using the roots as feed, the tops make excellent forage. (2) Sweet potato starch has certain qualities which make it peculiarly valuable in some manufacturing and industrial lines (see "Starch"), and the U. S. Department of Agriculture is undertaking to stimulate its production in the southern states, where much cotton land is idle. Conditions are more favorable here and it would seem that Hawaii could succeed in this line even better than the cotton states. (3) As a canned food the sweet potato is in good demand. Since the quarantine would not affect the canned product, it might be possible to develop a large industry on this basis, for the Hawaiian sweet potato is of good quality and by further selection and

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<sup>25</sup>These yields were on small experimental plots, probably not capable of duplication on a large scale, commercially.

breeding a type suitable for canning could be developed.

Present production occupies about 250 acres, including small garden plantings. This is barely enough to meet the local market demands. It grows well at any elevation from sea level to 2000 feet, and is adapted to a wider range of soil types than many other crop plants.

See also "Starch."

Ref.—U. H. Agr. Ext. Bul. 16:115-123, 1932 (an excellent and practical guide for production and harvesting); Haw. Exp. Sta. Bul. 50 (The Sweet Potato in Hawaii), 1923; Bul. 22 (Sweet Potato Insects), 1911; Annual Reports 1901:375; 1910:36; 1918:49; 1919:46; 1921:27; 1923:6; 1924:12; 1925:10; 1926:11; 1927:13; 1928:14; 1936:23; U. H. Agr. Dept. Annual Reports 1919:24-26; 1920:15, 21-24. U. S. Dept. Agr. Yearbook 1935, pp. 308-9.

**SWEET SOP** The sweet sop (*Annona squamosa*) is a tropical rarity seldom found in gardens in Hawaii and not at all planted commercially. It resembles the cherimoya, which see.

**SWEET VERNAL GRASS** Sweet vernal grass (*Anthoxanthum odoratum*) is widely distributed in the higher elevations of all islands. Cattle do not eat it readily and it may become a pest.

Ref.—Haw. Exp. Sta. Bul. 65:8, 1933.

**SWINE**<sup>26</sup> Swine were found in Hawaii when Captain Cook made his discovery voyage. Records show that he left a pair of English breed pigs in 1778 but little definite information seems available as to other sources of breeding stock until the beginning of the present century.

During the whaling era there was a steady demand for pigs to replenish the food supplies on the vessels which put into port. Also, in the 1850's a brisk business developed in the exporting of swine to California. President W. L. Lee of the Royal Hawaiian Agricultural Society noted in 1853 that "the demand for live hogs for exportation to California exceeds the production and hardly a vessel leaves for San Francisco that does not carry a deck load of grunTERS. They are worth 4 to 6 cents per pound on foot and the business of raising them is within the scope of the natives and pays well." In the transactions of the

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<sup>26</sup>This statement was prepared by Prof. L. A. Henke.

same society for 1855 a record appears that a Berkshire imported boar was awarded the first prize. Other breeds have been introduced since then, but Berkshires are still one of the most popular breeds, along with Duroc-Jerseys and Tamworths. Some Chester Whites and Poland-Chinas have been introduced, but they occupy a secondary position to the first named breeds and crosses of these breeds.

Since 1900 rather definite records are available and they show that there has been a gradual increase in the number of pigs in the Territory, although there have been times during this period when interest in swine raising was at a low point due to the large numbers of live pigs shipped to Hawaii from California for immediate slaughter. Swine raising in this Territory is largely concentrated around the larger cities and towns, and garbage from homes, hotels, and army posts is one of the major feeds used. However, for satisfactory gains it is necessary to supplement garbage with some concentrates which cost far more in Hawaii than in the corn belt. Experiments<sup>27</sup> at the University of Hawaii have demonstrated that cane molasses can be advantageously used as part of the ration fed to swine and increasing quantities of molasses are being used in this way, resulting in a material reduction in the cost of pork production (see "Molasses").

Garbage from homes is secured at no cost by hog raisers, other than collection costs, which may be considerable in some cases; restaurants, hospitals and hotels receive some pay for their garbage, and garbage from army posts is sold on competitive bid, which ranges around 20 to 35 cents per man month.

The number of hogs in Hawaii during recent years as shown by the U. S. Census follows:

<i>Year</i>	<i>Number of swine</i>
1900.....	8,057
1910.....	20,484
1920.....	38,940
1930.....	42,841

<sup>27</sup>For a report on recent feeding experiments see Haw. Exp. Sta. Annual Report 1936:70-72.

Practically all pork produced in Hawaii is consumed as fresh pork, and cured meats are almost entirely imported. The extent of these imports during recent years follows:

#### IMPORTS OF HOG PRODUCTS TO HAWAII

##### HAMS, SHOULDERS, AND BACON

<i>Year</i>	<i>Pounds</i>	<i>Value</i>
1920.....	1,437,626	\$526,439
1923.....	1,584,057	459,874
1926.....	1,221,242	480,387
1929.....	2,118,917	714,924
1932.....	2,857,754	459,909
1935.....	2,604,740	715,339

##### FRESH AND PICKLED PORK

1920.....	146,270	34,299
1923.....	540,519	94,879
1926.....	874,178	217,318
1929.....	1,420,381	306,014
1932.....	2,350,267	245,131
1935.....	2,220,076	420,978

##### LARD

1920.....	40,850	9,944
1923.....	265,532	36,984
1926.....	130,836	22,396
1929.....	184,352	24,590
1932.....	159,052	10,490
1935.....	170,353	25,374

##### SAUSAGES<sup>28</sup>

1920.....	201,788	79,566
1923.....	551,360	125,485
1926.....	825,491	223,169
1929.....	1,115,135	285,838
1932.....	2,028,811	304,586
1935.....	2,605,873	500,132

In general it appears that pork products imported to Hawaii have increased somewhat during the years shown with a grand total of 7,601,042 pounds for 1935 valued at \$1,666,823. To produce these amounts locally would require that approximately 50,000 additional hogs be produced and marketed annually.

Exact data on local production are hard to secure because many pigs are killed in various small slaughter houses. Based on available data, it is estimated that approximately 40,000 pigs are slaughtered annually in Hawaii, having a total weight of about 6,000,000 pounds and valued at about \$800,000.

<sup>28</sup>May include some other meats.

Based on available data, per capita pork consumption in Hawaii averages about 35 pounds per year, which is about half of the per capita consumption on the mainland.

In addition to the pork products reported above, the following numbers of live hogs have been imported to Hawaii in recent years:

<i>Year</i>	<i>Live hogs shipped to Hawaii</i>
1929.....	6740
1930.....	5178
1931.....	3100
1932.....	4259
1933.....	3080
1934.....	1728
1935.....	15

Hog cholera is found in the Territory and some of the hog raisers regularly immunize their pigs. Many others, however, resort to vaccination only when outbreaks occur and heavy losses occasionally result.

Round, intestinal worms are prevalent in many piggeries and occasion some losses by causing the death or stunting of small pigs. These losses can be largely avoided by proper sanitation and treatment with worm remedies; the Agricultural Extension Service of the University is doing valuable work along these lines.

Many hog raisers have a very limited area of land and many pigs are born and go to market without ever having had access to pasture areas. Some hog men may have as many as 500 pigs on an area of one acre or less.

Data compiled by the Board of Health show the following number of pigs and pig raisers on Oahu in 1936:

	<i>Hog raisers</i>	<i>Number of pigs</i>
City of Honolulu.....	195	19,460
Rural Oahu .....	214	7,241
	409	26,701

Unfortunately, similar data for the other islands do not seem to be available.

**SWISS CHARD** Swiss chard (*Beta vulgaris cicla*) is a relative of the beet. Its leaves have thick, fleshy midribs and are excellent when cooked as greens, or the midribs

may be separated from the leafy portion and used as a substitute for asparagus.

The plant grows to perfection in Hawaii<sup>29</sup> and should be cultivated extensively. Unfortunately, it is not well known and the market demand for it is limited, which causes gardeners to plant it but sparingly.

See also "Truck Crops."

**TALL OATGRASS** Tall oatgrass (*Arrhenatherum elatius*) is of moderate importance on Lanai as a pasture grass.

Ref.—Haw. Exp. Sta. Bul. 65:9, 1933.

**TAMARIND** The tamarind (*Tamarindus indica*), one of the most beautiful of ornamental trees, grows exceedingly well in Hawaii and may be found in many yards and gardens. Although it has been recommended from time to time as having commercial possibilities as a source of fuel wood and timber, it is considered throughout the Islands as nothing more than an ornamental.

The fruit of the tamarind tree is a somewhat fleshy pod, from which may be extracted a juice of an agreeably acid flavor. In Mexico this juice is much prized as a refreshing drink when greatly diluted with water and sweetened. In Hawaii, however, this use of the fruit seems not to have developed,<sup>1</sup> and the pods simply waste away on the ground or are eaten by swine. In India the seeds are cooked and ground into meal, but the flavor is sometimes bitter.

Ref.—Trans. Royal Haw'n Agr. Soc. Vol. I, No. 2, p. 83 (1851); Haw. Exp. Sta. Annual Report 1921:20; Bul. 77:83-85 (uses, recipes, etc.); Haw. For. Agr. 1908:124.

**TAN-BARK** The bark of several kinds of trees has been used in Hawaii for securing the tannin necessary in curing and tanning leather. The three kinds used most commonly are koa, ohia and kukui (candle nut tree). Koa (*Acacia koa*) contains a good amount of tannin and has been used for over a century; it makes a rather dark colored leather. Ohia (*Metrosideros*) makes a relatively

<sup>29</sup>Krauss—Agr. Ext. Bul. 16, p. 70, 1932.

<sup>1</sup>The Planters Monthly Vol. XII, p. 531 (1893) gives directions for the "preserving" of tamarind pods, but there is no indication that it was a common use of this product.



light colored leather. Kukui (*Aleurites*) has the most tannin of any of these three and is therefore the strongest for tanning. Algaroba bark is said to have good tanning properties, also.

The sumach, or neneleau (*Rhus semialata sandwicensis*) was long ago<sup>2</sup> found to be useful, especially in the tanning of fine kid skins. Thinking that there might be the basis of an industry in the furnishing of large quantities of this bark to the mainland trade, Mr. G. P. Judd in 1868 sent a keg of it to a Boston manufacturer for trial, the letter<sup>3</sup> accompanying it saying that he supposed that it "may be the same as the Italian or Sicily sumach, used in woolen manufacture, also in tanning morocco skins." Mr. Judd said that if the local sumach was good, "any quantity required" could be shipped. Nothing of commercial importance developed, although it was mentioned from time to time as a possible basis of an industry.<sup>4</sup> Many years later (1918) a plan to develop an industry by growing sumach trees in plantation form was developed, but soon abandoned when it was discovered that a disease was destroying many of the wild sumach trees in the Hamakua forests, where they had in earlier times been abundant. It was feared that the disease would make commercial production unprofitable, if not impossible.

In 1905, an effort was made to demonstrate the possibilities of producing tan-bark on a commercial scale. This time it was not sumach bark, however, but the black wattle tree (*Acacia decurrens*), and the test was made by the Hawaii Experiment Station. A stand of these trees (6 acres) planted in 1890 was cut down and the bark stripped off, dried and sold for tanning purposes. The tannin content was good, and the returns from the bark together with the fuel wood sold were at the rate of \$254.84 per acre. Director Jared Smith concluded "that wattle bark cultivation would prove a profitable industry in parts of Hawaii, as the trees grow as well in Hawaii as anywhere in the world."

Another possibility in this line is the extraction of

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<sup>2</sup>Mentioned in 1853 as an established practice (see first item under "Ref." at end of this article).

<sup>3</sup>In private files of Judd family.

<sup>4</sup>As in *Planters Monthly* Vol III, p. 592 (1884).

tannin from avocado seeds, which are known to be rich in this substance.

Tannin manufacture seems to be one of the many latent possibilities which Hawaii may develop when other and more attractive things have been exploited.

Ref.—Trans. Royal Haw'n Agr. Soc. 1853, p. 86; Haw. Exp. Sta. Annual Report, 1905, p. 11; Haw. For. Agr. 1904:151 (J. G. Smith, on black wattle); 1918:441 (Sumach); Planters Record (H.S.P.A.) IV, p. 82 (1911).

**TANGERINE** See "Mandarin Orange."

**TANNIN** See "Tan-bark."

**TAPA** The making of tapa, or kapa, is a Polynesian art many centuries old. Once important for its furnishing clothing material, it now is little more than a tourist attraction.

Tapa is a forest product, for it is made by removing the inner bark of various kinds of forest trees and beating it into a fibrous cloth-like article to be decorated with vegetable dyes applied in typical patterns.

Much of the tapa cloth offered for sale in Honolulu is imported from Samoa, but a movement is now under way to revive this old industry as a means of giving some Hawaiian families a means of livelihood.

For an excellent and authoritative account of the art of making this distinctively Polynesian product, see an article by the late Dr. W. T. Brigham, once Director of the Bishop Museum, in:

Ref.—Thrum's Annual for 1896, pp. 76-86, "Hawaiian Kapa Making."

**TARO** Taro (*Colocasia esculenta*) is probably the most ancient of Hawaiian agricultural crops. It is believed to have been brought here by the earliest Polynesian immigrants, forebears of the present Hawaiians, for it is the staff of life throughout Polynesia and would inevitably have been carried as food by voyaging parties.

The entire plant is capable of being used as food. The bulb-like root (corm) is cooked and eaten either as a vegetable or is mashed, kneaded and fermented to make poi; or it may be made into starch or flour. The leaves may be cooked and eaten as greens. The leaf stalks (petioles) and stems, when cooked, are succulent and tender like swiss chard or asparagus. The flowers are cooked to make

a dish that is especially delectable to Hawaiians. The skins and refuse left after cooking the corms are used as feed for pigs and poultry. Since the tops are usually in demand as planting material, they do not come into market for use as a food very abundantly.

Cultivation of the taro by the ancient Hawaiians was developed to an astonishingly high degree of efficiency, as attested by the fact that the relatively limited shore plain lands were made to yield enough of this staple to maintain a population of about 300,000 people in good health and vigor. They practiced selection in planting and thereby developed a large number of recognized and named varieties,<sup>5</sup> each differing from the others in some essential characteristic. They handled the taro plant usually as an aquatic, growing it in small, diked basins which could be kept partially filled with ever-changing water by allowing a stream to flow through a series of such basins, each varying in area from a few hundred square feet to a quarter of an acre, according to the contour of the land. The early Hawaiians became skillful engineers in manipulating rivers and streams to bring them through their cleverly terraced taro lands. Their system of water rights, protecting the individual farmer in an exceedingly complicated network of irrigation canals and ditches, was so eminently fair and effective that it was incorporated bodily into the new set of laws established when the Islands were annexed to the United States.

Although this aquatic form of cultivation has always been used in Hawaii for most of the taro production, and certain varieties of the plant have become so accustomed to it that they will not grow well under any other conditions, there are varieties which do not require submergence and will thrive with only a moderate supply of irrigation water or rainfall. These are called "dryland" or "up-land" varieties, in contrast to the usual designation "wet-land" for the aquatic or semi-aquatic types. As a general rule, the dryland varieties are not used for poi making, but are cooked and eaten as vegetables.

The early Hawaiians, of course, had no commerce with the outside world. Later, after Captain Cook had opened this paradise to the world, its staple food, taro, did not

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<sup>5</sup>See Thrum's Annual 1880:28-29.

figure much in outside trade as did the sweet potato, pork and other articles of Hawaiian diet. Although foreigners of whatever race coming to these Islands to live learned to use and like taro, commerce never took it up. In a long list of exported products published in 1851,<sup>6</sup> for example, taro does not appear.

During the nineteenth century, as the total population of Hawaiians diminished as a result of the impact with western civilization, the production of taro decreased rapidly, and what there was left of it began to be taken over by the Chinese. By the end of the century it was noted<sup>7</sup> that about half of the production of taro was by Chinese farmers and that 80 per cent of the poi manufacturing was done by the Chinese. This trend has now gone further, to the point where practically all poi manufacturing is in the hands of Chinese, and Hawaiians constitute much less than half of the taro producers. At the present time, taro production for poi making purposes occupies only about 1500 acres of land, which is small in contrast to the total area which must have been devoted to this crop in the ancient days. Much of our present production is by Japanese farmers who grow not only the so-called Japanese taro, a dryland type with relatively small corms used as a vegetable, but in many cases are producing ordinary taro for the poi factories.

Taro requires ten to fifteen months to mature sufficiently for harvesting of the corms, and the yield is ordinarily six to ten tons of corms per acre, although under very good cultivation it may yield as much as fifteen tons. Worthy of note, too, is the fact that taro is considered much more valuable as a food than most of the starch crops mentioned above, and commands a sufficiently higher unit price in the market to make its cultivation profitable. The starch grains of taro are believed to be perhaps the most easily digestible of all known to commerce, while the combination of ingredients placed by nature in taro seems to be unusually nutritious and healthful.

Knowledge of this fact, now that there is a widespread interest in the diversification of agriculture in Hawaii, is causing some of our leaders to give careful consideration

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<sup>6</sup>Trans. Royal Haw'n Agr. Soc. 1851, p. 87.

<sup>7</sup>Haw. Exp. Sta. Annual Report 1901, p. 376.

to taro production as the possible basis of a very large industry, no longer to depend wholly on local consumption but to seek a world-wide market as a means of stabilizing conditions for the producer.

To this end, the Hawaii Experiment Station has recently undertaken a comprehensive and intensive program of research<sup>8</sup> to accomplish the following objectives: (1) devise processes for transforming taro into forms of food with which the American public is familiar, as flour,<sup>9</sup> breakfast foods, beverages, etc.; (2) develop the best possible cultivation techniques, including fertilization, especially for the varieties which do not require aquatic conditions, for there are much greater land areas available for the dryland varieties than for the more common wetland types; (3) find the best means of controlling several pests and diseases of taro which cause serious losses at the present time (sometimes destroying 50 to 75 percent of a field); (4) ascertain by the best scientific methods the true values of taro as a food. Effective cooperation in these investigations is being given by the Hawaiian Sugar Planters Association, the Queen's Hospital, the Territorial Board of Health, and other agencies.

This is a large undertaking but promising results are already appearing in all the four subdivisions. It may be that taro will again take a conspicuous place among the crops of these Islands, for there are very extensive areas of land now unused which would seem to be suitable for the dryland type of culture, and there is a possibility that this crop might prove to be more profitable than some others now in cultivation and might displace them.

Ref.—U. H. Agr. Ext. Service, Agr. Notes No. 129, Apr. 4, 1936 (culture of dryland taro); Thrum's Annual 1880:28-29; 1887:63-65; Haw. Exp. Sta. Annual Reports 1901:375; 1902:310; 1903:396; 1910:18, 64; 1912:56; 1915:39; 1919:50; 1920:39; 1921:28; 1925:10; 1926:12; 1927:13; 1928:14; 1936:8, 10, 22, 33-37, 54-58; also current (unpublished) reports of progress available in mimeographed form; Haw. For. Agr. 1913:186, 225, 280, 315, 249, 371 (series of articles by MacCaughy).

<sup>8</sup>For a report on these investigations and experiments see Haw. Exp. Sta. Annual Report 1936, pages 8, 10, 22, 33-37 (diseases), 54-58 (processing).

<sup>9</sup>Taro flour was manufactured here in the 1880's; in 1887 some 4230 pounds of it were exported for trial in the United States, and another lot of 5100 pounds in 1891. No important results followed. Later, in the present century, two ventures were made in the same line, one calling the flour "taro-ina" and the other "taromano." Neither was successful commercially.

**TEA** The first introduction of the tea plant (*Thea sinensis*) into Hawaii was by W. H. Purvis in 1887, his seed having been obtained from Ceylon. His trial planting was near Kukuihaele, Island of Hawaii. The results were sufficiently encouraging so that in 1892 the Hawaiian Coffee and Tea Company planted about 5 acres in the Kona district, with the expectation of developing an extensive industry.

It was soon realized, however, that because wage rates here were higher than in India and other tea-producing countries competition was quite impossible. This initial effort was abandoned and no serious effort has been made subsequently to establish an industry on this commodity.

See also "Yerba mate."

Ref.—Thrum's Annual 1893:106; Planters Monthly XIII, pp. 342-344 (1894).

**TESOTA BEAN** The tesota bean (*Olneya tesota*) is a leguminous tree, somewhat similar to the algaroba and koahaole in its preference for arid surroundings. Its nutritious pods and foliage are relished by cattle and afford a good source of feed in dry regions.

A trial introduction was made by C. S. Judd in 1922 but thus far it has not become an important feature here.

Ref.—Haw. For. Agr. 1922:224.

**TI** Ti, or ki (*Cordyline terminalis*) is a native plant of Hawaii. Its leaves have long been used by the Hawaiians for wrapping food and other articles, and as a substitute for plates; also to cover food placed in underground ovens. The coolness of the leaves relieved headache and fever.<sup>10</sup>

The root, which is really a greatly enlarged<sup>11</sup> prolongation of the stem, has long been used as a source of alcohol in the making of a beverage called "okolehao." This has a recognized place in the alcoholic beverage trade, and since the repeal of the prohibition act some efforts have been made to revive a once thriving industry in the manufacture of this product from ti-root.

Investigations now under way at the laboratories of the H. S. P. A. Experiment Station indicate some very great

<sup>10</sup>Thrum's Annual 1923, p. 71.

<sup>11</sup>Often weighing 30 to 40 pounds and sometimes much more.

possibilities in the extraction of levulose sugar from the root and stem of ti, as the inulin content is large.

**TOBACCO** Tobacco (*Nicotianum Tabaccum*) is a crop which is in very large demand and produced in many parts of the world. The United States, for example, has nearly 2 million acres devoted to tobacco production in an average year, this being scattered in twenty different states. The U. S. Department of Agriculture Yearbook (1935) shows some 46 countries engaged in the production of this crop, with about 4½ billion pounds estimated as the probable total crop of the world. By far the largest producer is the United States.

Hawaii is known to have some excellent locations and soils for this crop, and a good deal of money and effort has been spent to develop an industry here, but thus far there has been no lasting success. There is virtually no tobacco grown in this Territory on a commercial scale at the present time.

Probably the first planting of tobacco in these Islands was by Marin about 1812, and from this beginning it spread somewhat into general but very limited cultivation by Hawaiians.

With the forming of the Royal Hawaiian Agricultural Society in 1850 the idea began to be advanced with a good deal of determination that tobacco could be made a very important crop here. In 1854, A. Archer reports at length<sup>12</sup> on commercial trials made by himself and others, all with poor or no success, due largely to lack of knowledge about both culture and curing of the crop. He concludes his report with the optimistic declaration of his belief that "tobacco will ultimately be one of the best paying crops raised here and nothing but time is required to enable us to compete successfully with Manila and Havana."

The Hawaii Experiment Station, when it was under the direction of Mr. Jared Smith, went extensively into experiments on tobacco production and curing, beginning in 1901. With financial assistance from several interested citizens, the Station tried this crop on a small experimental scale both in the Hamakua and the Kona districts of the

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<sup>12</sup>Trans. Royal Haw'n Agr. Soc. Vol. II, No. 1, pp. 46-52, 1854.

Big Island, as well as elsewhere, with good results. It was believed from this preliminary experience that wrapper tobacco of the Sumatra type could be produced here which was fully the equal of the best in the world. Yields of 1000 to 2000 pounds per acre of good wrapper leaf were reported.<sup>13</sup>

The experiments by the Station encouraged private enterprise to try the industry. In 1906 a commercial project was undertaken in Hamakua, with 15 acres as a trial farm. In 1908 a tract of over 200 acres in Kona was planted, with an investment of something over \$25,000 in fields, implements, curing sheds, and labor.<sup>14</sup> From this beginning the industry grew lustily for three years and seemed to be on the way to success.

In 1912 a very disastrous fire occurred, destroying a large curing shed and packing house and the tobacco stored therein; this happened to include not only the whole crop of that year of the pioneer company, but also the product of certain other newer producers which was stored there for curing and was destroyed with the rest. All together, there were about 100,000 pounds of tobacco lost in that fire, according to Mr. Jared Smith. This proved to be the beginning of the end, for the young industry never fully recovered from the disaster.

In the ensuing years, Jared Smith and others made repeated efforts to put this industry on its feet. Several new ventures were made, mostly in the Kona district, and a great deal of money was invested. In 1916 W. R. Castle took over the remnants of the original company and tried to rehabilitate it, but with no success. In 1919 he withdrew from all business activities, including his tobacco company, but declared his belief that tobacco production could be developed into a good industry here. Several smaller ventures by Smith meanwhile had met with enough success so that he was able to say,<sup>15</sup> "After many reverses and false starts, by 1919 I had worked up a profitable local business, and was selling cigars" through a local wholesale house and also through a Seattle agency.

<sup>13</sup>See Haw. Exp. Sta. Bul. 15.

<sup>14</sup>Mr. J. G. Smith resigned the directorship of the Hawaii Experiment Station in 1908 to take charge of these operations in Kona.

<sup>15</sup>Honolulu Advertiser, Nov. 13, 1934.



In 1920 Castle's old company was reorganized by others under a slightly different name and a crop was produced that year but none thereafter. Smith continued, however, until "the 1929 panic brought the end of dreams." Then he, also, withdrew and the Hawaiian tobacco industry was no more.

The following table of annual exports of tobacco from Hawaii shows the extent to which this industry was developed. The yearly crops did not fluctuate as greatly as the table would suggest, for it was the practice in some years to hold some or all of the crop in storage, to be marketed perhaps with the succeeding year's crop:

TOBACCO SHIPMENTS

<i>Year</i>	<i>Value of Exports</i>	<i>Year</i>	<i>Value of Exports</i>
1907.....	\$ 1,914	1917.....	1,205
1908.....	2,772	1918.....	25,910
1909.....	4,719	1919.....	12,647
1910.....	15,644	1920.....	8,802
1911.....	4,114	1921.....	1,438
1912.....	94,978	1922.....	3,097
1913.....	Destroyed by fire	1923.....	1,385
1914.....	1,277	1924.....	20,608
1915.....	26,832	1925.....	2,770
1916.....	4,420	1926.....	4,142

Ref.—Haw. Exp. Sta. Bul. 15; Annual Reports 1903:402; 1904:366; 1905:13; 1906:13; 1907:13; Thrum's Annual 1906:156; 1917: 154; 1921:97-99; Hon. Advertiser, Nov. 11, 12, 13, 1934 (articles by Jared Smith); Haw. For. Agr. 904:345-348 (J. G. Smith, summary of experimentation); 1909:76-78 (Smith, on possibilities—30,000 acres available).

**TOMATO** The tomato (*Lycopersicum esculentum*), a member of the nightshade family of plants, is very widely cultivated for its juicy, edible fruits. A small-fruited variety grows wild in many parts of this Territory, from sea-level to 5000 feet elevation, apparently having established itself here several centuries ago, for the ancient Hawaiians used it both for food purposes and medicinally, as well. The fruit is nearly spherical and about a half inch in diameter; the vine is an annual, one to three feet high, and occurs commonly in pastures and abandoned fields. It is not to be confused with the popolo, a large, spiny

shrub which bears poisonous, tomato-like fruits an inch or so in diameter. This latter is another species (*Solanum aculeatissimum*), sometimes called "kikania"<sup>16</sup> because of its spininess; it was introduced in the nineteenth century and now is widely distributed, growing wild as a common part of the foothill shrubbery.

The common (European) type of tomato was introduced soon after the coming of white people, Marin mentioning it in his diary about 1813;<sup>17</sup> probably many had it in their home gardens. There were no very serious obstacles to contend with, other than the common blight and several kinds of noxious insects, until the melon fly gained admission to the Islands at about the beginning of the present century. This fly became a pest of major importance, causing the destruction of half or more of the tomato crop each year. Although the Hawaii Experiment Station began some tomato experiments in 1903, interest in this crop was at such a low ebb, chiefly because of the melon fly handicap, that no more attention was given to it until 1916, when the threatened food shortage during the World War altered the local situation.

Aside from the desirability of having a locally produced supply of tomatoes available in a time when the normal movement of ships might be interrupted, there was the fact that large quantities were being imported, both fresh and canned, amounting in value to about \$100,000 per year, which might well be produced by our own farmers. The chief obstacle to this being the melon fly, efforts were begun in 1916 by the Experiment Station to cross the small, commercially valueless wild tomato with some of the imported varieties, for it was known to be immune to this insect pest and it was believed that an equally immune but commercially marketable type might be obtained as a hybrid. While the results were not wholly successful, several strains were developed which had good market possibilities and at the same time were more resistant to melon fly attacks than were the imported varieties. The best was a cross between the Earliana and the small native variety, in one year (1924) 7000 seedlings

<sup>16</sup>Kikania is applied more commonly to the cockle-bur and sometimes to the jimson weed (*Datura stramonium*).

<sup>17</sup>Trans. Royal Haw'n Agr. Soc., 1850, p. 46.

or packets of seeds of this having been distributed to farmers and householders.

Interest grew rapidly in the production of tomatoes for market, attention shifting after several years from the locally produced hybrid to certain mainland varieties which, because of the globular shape of the fruit and absence of surface ridges, were found to be moderately resistant to the melon fly. As parasites increased their inroads on this pest its attacks on the tomato crop became less serious and growers increased their plantings. At the present time over 400 acres are devoted to this crop.

Attention is now being directed toward better marketing methods. Until recently there has been little or no effort made by producers to grade their tomatoes and to offer them in an attractive way to the consumers. This now is being done in some instances, with such good pecuniary results that others will probably do likewise.

In view of all these developments and because climatic and soil conditions here are so favorable for this crop, Dr. F. G. Krauss has stated<sup>18</sup> it as his belief that "tomato production in Hawaii offers as great an opportunity for the local market gardener and truck farmer as any vegetable crop. There is not only a heavy demand for local consumption throughout the year, but there are great possibilities for canning and for exporting fresh tomatoes," the latter depending, of course, on some modification being made in existing quarantine restrictions placed on many crops here (including the tomato) by the federal government because of the fruitflies. With such a modification permitting exportation, there would be a very large market open to local growers during the winter and early spring months when mainland consumers have to look to Mexico to supply their needs. There is a duty of three cents per pound on Mexican and other foreign tomatoes.

Ref.—U. of H. Agr. Ext. Bul. 16:126-136; 1932 (full information on cultural practices, disease control, harvesting, marketing, etc.); Haw. Exp. Sta. Annual Reports 1903:397; 1918:19; 1921:23, 33; 1922:7; 1923:5; 1924:9; 1936:25, 33, 37.

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<sup>18</sup>U. of H. Agr. Ext. Bul. 16, p. 126, 1932.

**TREE FERN** Several species<sup>19</sup> of fern in Hawaii grow to large enough proportions to justify the name "tree fern." The trunks of these "trees" have large cores which are an excellent source of starch (see "Starch"). The early Hawaiians discovered this and made practical use of it; in recent years an effort was made to develop an industry on it, but without success.

*Pulu*—These tree ferns produce an abundance of woolly silk at the growing point of the stalk, called by Hawaiians "pulu." It was long ago discovered that pulu is good for stuffing pillows and mattresses, and a very thriving industry developed in the 1850's and continued for nearly 30 years in shipping this material to California to be used in upholstery and mattress making. The best years were 1872-1875, when the annual shipments averaged a little better than a half million pounds, but in the subsequent years the industry diminished rapidly when California began producing cotton. An effort to establish an export business to Australia in the 70's looked promising for a time, but did not develop successfully. While it lasted, this industry was financially profitable to Hawaii, for pulu commanded a good price, from ten to fifteen cents per pound, and yielded a revenue of \$30,000 to \$60,000 per year.

In spite of the large monetary returns the industry had its drawbacks, however, and many felt relieved when it passed out of existence. The work of collecting pulu for market was full of great hardship and sometimes tragedy, for it took many people far up into the rainy mountain forests for days and weeks at a time, thus breaking up families and causing sickness, which often resulted from the lack of adequate food and the perpetual wetness of the fern forests; in general, the human aspect of the industry was anything but satisfactory. It is one of those interesting and dramatic, though tragic, chapters in the history of Hawaii which are more easily told than ex-

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<sup>19</sup>There are four species usually called tree ferns; three of them are closely related and are the largest, sometimes growing to heights of 30 or 40 feet: *Cibotium menziesii*, *C. glaucum* and *C. chamissoi*; the latter is commonly known by its Hawaiian name, "hapu." Another, and smaller, species of tree fern is the *Sadleria cyatheoides*, called by Hawaiians "amau."

perienced. The sandalwood trade was another similar episode, on a larger scale.

See also "Fern Tips" and "Starch."

Ref.—Export figures in Thrum's Annual, 1878, p. 58; see also, 1929:77-82 for an excellent description of the industry.

**TRUCK CROPS** This is a general term frequently used in referring to a large miscellany of crops cultivated for food purposes, including not only those which are usually known as "vegetables," but also some fruits such as melons, tomatoes, etc.

The truck crops which are produced in Hawaii have been introduced from many parts of the world: from the South Sea Islands by the early Hawaiians, from America and Europe by the white people, and from Asia by the Orientals. This has resulted in there being here a wider range of these food crops than would be found in any other place of comparable size.

The semi-tropical climate of Hawaii is favorable to the production of a large number of truck crops, but there are a considerable number of others which seem to require temperate zone conditions and therefore are not easily produced here. Some of these latter can be and occasionally are produced here on a small scale but with relatively poor results as to quality; in the cost of production, also, we are usually at a disadvantage in such cases as compared with the areas which make a specialty of their cultivation on a large scale.

One sometimes hears it said that the vegetables produced in Hawaii are lacking in flavor or in nutriment because of the alleged lack of iron in the soil. For such a statement there is absolutely no justification. The soil is *not* lacking in iron, and there is abundant scientific as well as culinary evidence that Hawaiian-grown vegetables and fruits are as nutritious as those produced elsewhere. The flavor of fruits and vegetables sometimes varies from one locality to another, and a person accustomed to a certain flavor in a given kind of food may not find it exactly duplicated when he moves his place of residence; these differences in flavor do not, however, mean less nutritional value. As a matter of fact, the freshness of vegetables grown here should render them more nutritious than the

imported articles, and therefore superior and capable of commanding a slightly higher unit price. Unfortunately, the local product is usually in less demand and brings a somewhat lower price, probably because by better grading and packaging the imported vegetables and fruits present a better appearance. As soon as local producers learn the value of this and emulate the practices of their larger and more experienced competitors abroad it may be that the Hawaiian-grown product will stand on an equal footing in the matter of unit prices.<sup>20</sup>

Directions for the planting and care of many of the truck crops producible here are given in some detail by Dr. F. G. Krauss in a bulletin<sup>21</sup> which was published in 1932 as a practical help both to commercial producers and home gardeners. Another valuable guide, especially in the cooking of vegetables, is H. L. Chung's bulletin on Oriental vegetables.<sup>22</sup>

The following classified list of truck crops includes only those which are or have been produced in Hawaii. Some information concerning each may be found by referring to it in its proper alphabetical position.

#### CLASSIFIED LIST OF TRUCK CROPS

##### I.—*Root*, the Edible Portion:

Arrowhead	Lotus-root
Arrowroot	Onion
Beet	Oyster plant (salsify)
Burdock (gobo)	Parsnip
Carrot	Potato
Daikon	Radish
Dasheen (Japanese taro)	Salsify (oyster plant)
Garlic	Sweet Potato
Ginger	Taro, Japanese
Gobo (burdock)	Turnip
Horse-radish	Water Chestnut
Japanese taro (dasheen)	Yam
Kudzu	Yam Bean Root

<sup>20</sup>For a report on recent developments in marketing local truck crops see Haw. Exp. Sta. Annual Report 1936: 66-68.

<sup>21</sup>Commercial Vegetable Production in Hawaii—Agr. Ext. Bul. 16, published by the University of Hawaii in June, 1932. See also, U. H. Agr. Ext. Service, Agr. Notes 120, Dec. 4, 1935 (Varieties suitable for Hawaii).

<sup>22</sup>"Utilization and Composition of Oriental Vegetables in Hawaii," Bul. 60 of Hawaii Exp. Sta., 1929.

II—*Stem* or *Petiole*, the Edible Portion:

Asparagus	Fern Tips
Bamboo shoots	Kohlrabi
Bean sprouts	Rhubarb
Butterbur	Taro shoots and stalks
Celery	

III—*Leaf* (sometimes with stem), the Edible Portion:

Beet greens	Matrimony vine
Brussels sprouts	Mint
Cabbage	Mugwort
Chinese cabbage	Mustard potherb
Chives	Parsley
Chrysanthemum	Perilla
Collards	Radish greens
Coriander	Rutabaga
Dandelion	Spinach
Endive	Swamp cabbage
Honewort	Swiss chard
Kale	Taro tops
Leaf-mustard cabbage	Turnip greens
Leek	Watercress
Lettuce	Water dropwort
Malabar nightshade	

IV—*Flower*, the Edible Portion:

Artichoke	Cauliflower
Broccoli	Ginger

V—*Fruit*, the Edible Portion:

Balsam pear	Jesuit nut
Cantaloupe	Okra
Chayote	Pepper
Chinese melon	Pumpkin
Cucumber	Squash
Egg plant	Tomato
Gourd	Watermelon

VI—*Seeds*, the Edible Portion:

Beans	Corn	Peas
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TUNA See "Cactus."

**TUNG OIL** See "Kukui."

**TURKEY** The turkey was first introduced into Hawaii early last century and became a minor feature of some of the big livestock ranches. Little care was given the birds, however, and they wandered off into the forests and became semi-wild. At certain times, as Thanksgiving and Christmas, some are brought in by means of a drive, or by shooting, and thus the local market has been supplied, but only to a limited extent, for much the larger part of the local demand has been met by importing cold storage turkeys.

In the past few years several poultrymen in Hawaii have begun to take up the raising of turkeys in a more organized manner. The chief obstacle thus far encountered is the disease factor and the consequently high rate of mortality, for the turkey in its young stages is more difficult to raise than chickens. Another difficulty is the mongoose, which makes serious inroads on eggs and young. It is believed, however, that this industry offers some interesting possibilities for Hawaii, in spite of these obstacles.

See also "Poultry."

Ref.—Haw. Exp. Sta. Circ. 10, "Turkey Management in Hawaii," 1935.

**TURNIP** The turnip (*Brassica rapa*) is a member of the mustard family and is cultivated for its fleshy root. The leaves of young plants are sometimes used as greens.

Production in Hawaii is very limited, probably amounting to no more than an acre or two. Most of the local demand is filled by imports from the mainland, which amount to over 200,000 pounds per year. Locally produced turnips are apt to be fibrous and bitter when grown in the warm lowlands, and the mainland product is considered superior. Perhaps by selection and breeding a variety suitable for planting here could be developed.

The tops of young plants are used as greens, especially by the Chinese. Seedling plants eliminated in the process of thinning are tied in small bunches and offered in the market as turnip greens.

See also "Truck Crops."

Ref.—U. of H. Agr. Ext. Bul. 16:71, 1932; Haw. Exp. Sta. Bul. 60:29, 1929.



**UBA CANE** Uba cane, a variety of sugar cane, is used to a moderate extent here for green fodder purposes, but is not equal to elephant grass in quality nor in quantity of yield per acre.

Ref.—U. H. Agr. Dept. Annual Rep. 1918:12; 1919:12.

**VANILLA** Until chemistry showed the world how to make it synthetically in laboratories and factories, vanilla was a promising crop for Hawaii. Now it is just an interesting relic of the past.

Vanilla extract for a long time was made from the pods of an orchid plant (*Vanilla planifolia*) which was abundant in tropical Mexico and most of the South Pacific islands. It was first brought to Hawaii in 1884 by John Kidwell and was tried by him on a small scale on Oahu. The results of this trial were so good that Col. Spalding offered to finance Kidwell in a larger commercial venture if he would move to Kauai, but Kidwell declined.

The possibilities in this potential industry attracted a good deal of attention in the latter part of the nineteenth century, for the pods were commanding a very high price (\$15.00 per pound) in the world market and it was estimated that a grower could make anywhere from \$500 to \$5000 profit per acre. Hand pollination was required, which it was estimated would take eight persons to each acre.

Several undertook the cultivation of this new crop on a small scale, but there was very little progress toward establishing an industry.

In Kona, however, there was a fairly successful commercial venture in vanilla production by Capt. R. V. Woods, which prospered until chemistry changed the situation by greatly reducing the world price of this very expensive commodity. Some remnants of his vanilla plantation still exist, to recall the early days when there seemed to be promise of rich returns to the really good cultivator of this orchid crop.

Ref.—Haw. Exp. Sta. Press. Bul. 6; Annual Rep. 1903:402; 1919:37; Thrum's Annual 1904:66. Haw. For. Agr. 1904:268-273; 1905: 159-161 (cultural directions). Planters Monthly V, 142; VII, 42, 98, 466; X, 140; XVIII, 201.

**VEGETABLE IVORY** Vegetable ivory is the trade

name applied to the ivory-like seed of a palm (*Coelococcus carolinensis*), of which there are a few specimens growing as ornamentals in gardens and estates. While it may have some commercial possibilities here they have not as yet been demonstrated.

Ref.—Haw. Exp. Sta. Annual Report 1919:38.

**VEGETABLES** See "Truck Crops."

**VELVET BEANS** The velvet bean (*Stizolobium spp.*) is a temperate zone soiling crop which has been tried in Hawaii with moderately promising results.

Ref.—U. H. Agr. Dept. Annual Rep. 1920:15; 1929:54. Planters Record XI, 177 (1914).

**VELVET GRASS** Velvet grass (*Holcus lanatus*) grows above the 2000 foot level and is usually considered good for pasturage.

Ref.—Haw. Exp. Sta. Bul. 65:24, 1933.

**VETCH** Several varieties of vetch (*Vicia sativa*) have been tried a number of times in Hawaii for soiling and fodder purposes, but never with any promising results.

Ref.—U. of H. Agr. Dept. Annual Reports 1927:33; 1929:54.

**VINEGAR** Vinegar is a by-product of the pineapple industry, made in considerable quantities from excess juice by the California Packing Corporation. Practically all demand for bulk vinegar within the Territory is supplied from this source.

**WAIAWI** See "Guava."

**WALNUT** The walnut (*Juglans regia*) is a temperate zone tree which is grown sparingly in Hawaii at elevations of 4000 feet and higher, as on the slopes of Haleakala on Maui. There are a few fine trees on the Worth Aiken premises and the Von Tempsky's, and doubtless some in other similar localities on the other islands, but the total planting is very small and of no commercial significance.

**WAMPEE** The wampee, or wampii (*Clausena wampi*) is one of the more uncommon citrus fruits and in Hawaii is used occasionally as an ornamental, never for commercial exploitation of its fruits, which somewhat resemble the orange in flavor.

Ref.—Kuck and Tongg, "The Tropical Garden," p. 151.

**WATER APPLE** Several closely related species of *Eugenia*, introduced into Hawaii from the south Pacific tropics, produce fruits which somewhat resemble the mountain apple in structure and flavor. They are called "water apples" because of the watery texture of the pulp. They are uncommon in Hawaii, occurring in a few gardens. They are of little or no commercial importance.

**WATER BUFFALO** The water buffalo is an importation into Hawaii from Asia, present only in small numbers and used in the working of flooded rice fields where horses or mules would bog down. The cloven hoofs of this interesting draught animal enable it to plod its way, slowly but surely, even through the most sodden ground. With the waning of the rice industry in Hawaii, water buffaloes are much less in demand and the breeding of them is practically a thing of the past.

In one valley on Molokai the water buffalo was for a time living in the wild state. Having escaped many years ago, they multiplied and lived in the upper reaches of the well-watered valley. Hunters found them to be good game, because of a fierce disposition, and in time practically exterminated them.

**WATER CHESTNUT** The water chestnut (*Eleocharis tuberosus*) is an aquatic plant which produces an abundance of small, somewhat globular corms about an inch in diameter. These are much prized by the Chinese, who use them in the preparation of various dishes.

Production of the water chestnut in Hawaii is very limited, being only a specialty crop not often cultivated. A large part of the demand here, which is not extensive, is filled by imports from China, for it is considered that the foreign corms are sweeter and better flavored.

**WATERCRESS** Watercress (*Roripa nasturtium*) is a floating aquatic plant which thrives in fresh, running water but will grow in soil if sprinkled abundantly with water. Its foliage is somewhat succulent and has a peppery flavor, both of which characteristics make it desirable for use raw in salad dishes and sandwiches; it is often used, also, in the cooking of vegetable preparations.

Watercress occurs in the wild state in some places and

in others is in semi-cultivation. The latter areas all together probably are less than 50 acres, and are located mostly in the upper end of the well-watered valleys near Honolulu. The market demand is steady throughout the year, but never very great.

Care must be exercised in preparing watercress for eating raw, for it sometimes happens that it may be contaminated by liver fluke.

Ref.—Haw. Exp. Sta. Bul. 60:29, 1929. Haw. For. Agr. 1906:137.

**WATER DROPWORT** Water dropwort (*Oenanthe stolonifera*) is an aquatic plant with fragrant foliage which is used by the Chinese and Japanese as a soup flavoring. In appearance the foliage somewhat resembles that of celery. Its cultivation in Hawaii is limited.

Ref.—Haw. Exp. Sta. Bul. 60:30, 1929.

**WATERLEMON** See "Passion Fruit."

**WATERMELON** See "Melon."

**WATTLE** See "Tan-bark."

**WAX** Although a number of different kinds of plants are useful to commerce as sources of vegetable wax, in the case of only one in Hawaii has there been a serious effort at exploitation—sugar cane. In 1909 a quantity of the wax on the cane leaves was submitted to a manufacturing firm on the mainland specializing in wax products. It was hoped that an important industry might be developed here in the utilization of this obscure but possibly valuable by-product of the sugar plantations, for it was estimated that great quantities of the wax could be gathered.

The report from the laboratories blasted these hopes, however, for the wax of sugar cane was found to be of a decidedly inferior sort.<sup>1</sup> When used experimentally in the making of wax candles, it emitted a disagreeable odor, and had the further disadvantage of a very low melting point. The same defects made it useless for sealing wax, while for phonograph records it was not suitable. Even in the making of polishes it was not good because of too much greasiness.

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<sup>1</sup>For the full report see *Planters Record* Vol. II, pp. 373-381 (1910).

See also "Bayberry." The beef cattle industry produces some tallow as a by-product.

**WHEAT** The first recorded planting of wheat (*Triticum aestivum*) in these Islands was about 1815 by that versatile immigrant Marin, who tried his hand at so many things. The results of his trial planting could not have been very notable, for during the subsequent twenty years the opinion prevailed "that neither the soil nor climate of the Sandwich Islands was adapted to the raising of cereal grains,"<sup>2</sup> and none was to be seen growing. Surely there was incentive enough to try to raise wheat for the manufacture of flour, for imported flour in those days was more like concrete, after a long and wet voyage on a sailing schooner. The situation in those early years was picturesquely stated by J. S. Green<sup>3</sup> when he said "there was often a scarcity of flour, and what reached us from the U. S. was barely tolerable, occasionally too poor for feeding swine. On opening a barrel stamped 'Flour,' a chisel and mallet were always put in requisition to prepare the way for sifting, and these even were so ineffectual oftentimes that a pickaxe or crow-bar seemed necessary for the work" of breaking up the solid cake. Usually it was musty and sometimes sour, and often riddled with bugs and worms. "In those days the demand for saleratus was imperious" to alleviate the indigestibility of their so-called flour. "I have little doubt," declared the same commentator, "that the ill health of many of the early residents had its origin" in this imported flour.

Apparently, however, there had been a little growing of wheat since Marin's trial planting, for in 1835 a Kula (Maui) Hawaiian showed a little box of threshed and cleaned product to Mr. Green and asked what it was. Green told him, and urged him to plant some of it, explaining its value as food. The Hawaiians had been using it as stuffing for pillows to sleep on!

Within a few years it began to be abundant enough to appear in the markets in barrel lots. It was costly, however, for there were no mills and the grain had to be rubbed out on rough lava stones and the chaff blown off

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<sup>2</sup>J. S. Green, in Trans. Royal Haw'n Agr. Soc. Vol. I, No. 3, p. 98, 1852.

<sup>3</sup>Trans. Royal Haw'n Agr. Soc. Vol. I, No. 3, p. 98, 1852.

with the mouth. With Irish potatoes selling even at so low a price as a dollar per barrel there was more profit for the farmer in that crop than in wheat, and the latter had hard going as an industry in those years. It was estimated that the cost of growing and threshing wheat was nearly \$4.00 per bushel, before milling it into flour.

In 1848 a Mr. Edes introduced the cradle for more efficient harvesting of wheat, and there resulted a renewed interest in this crop. By 1852 there had developed the beginnings of a real industry, wheat growing, with nearly 140 acres devoted to it in the vicinity of Makawao, Maui. It was reported<sup>4</sup> that if enough seed had been available the acreage planted would have been "400 or even 500 acres; probably 100 acres by the natives." Most of the planting was by the white foreigners.

The following year more seed was available and some 1200 acres were planted on Maui, with small plantings on other islands. A power mill was erected in Honolulu and some 5000 barrels of flour manufactured in that year (part of 1853 and 1854), enough for home consumption needs. No longer was it necessary to break concrete blocks before one could eat his flour. The president of the Royal Hawaiian Agricultural Society, William Lee, gave vent to his feelings anent this when he declared fervently,<sup>5</sup> "for the last three months I have made Makawao wheat my staple food and I hope never to eat another ounce of imported flour."

Production flourished for a few years and became sufficiently extensive so that a few small export shipments were possible during the 1850's. This situation did not continue long, however, for California began about that time to produce wheat on a large scale at a lower cost than it could be grown in Hawaii, while at the same time sugar cane was claiming more and more of the attention, land and capital of these Islands and crowding out such things as wheat. Thus, this industry had a comparatively brief day in Hawaii, for by the late 1860's it was a thing of the past.

#### WHITE SAPOTA See "Sapota."

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<sup>4</sup>Wm. H. Rice in Trans. Royal Haw'n Agr. Soc. Vol. I, No. 4, p. 99, 1853.

<sup>5</sup>Trans. Royal Haw'n Agr. Soc. Vol. II, No. 1, p. 5, 1854.

**WI** The wi (*Spondias dulcis*) is a native of the Society Islands. The tree grows readily in Hawaii, being used chiefly as an ornamental. Its fruit is oval, 1 to 3 inches in diameter, smooth-skinned, with light yellow pulp which is good to eat when fully ripe, somewhat suggestive of the pineapple in flavor. There is a very limited amount of cultivation of this fruit for market, a recent crop survey showing scattered small plantings amounting to an acre or two all together.

Ref.—Wilder, "Fruits of Hawaii," p. 54.

**WILDER GRASS** Wilder grass (*Andropogon nodosus*) was first introduced into Hawaii by G. P. Wilder. It is still on trial and has not been generally disseminated.

Ref.—Haw. Exp. Sta. Bul. 65:5, 1933.

**WILLOW** A species of willow (*Salix vitellina*) commonly used in the manufacture of furniture was introduced into Hawaii from Madeira in 1909 by Dr. L. R. Gaspar.<sup>6</sup> It grew successfully in the vicinity of Honolulu, and some samples of furniture were made later from the canes. This experimental effort did not, however, lead to anything more extensive and this potential industry failed to materialize.

**WINE** See "Grapes."

**WOOL** See "Sheep."

**YAM** Yam is a name variously used, frequently referring merely to a large sweet potato, but when strictly used it applies to the enlarged root of an oriental plant known botanically as *Dioscorea batatas*.<sup>1</sup> The root is white-fleshed, usually somewhat cylindrical in shape, 6 to 18 inches in length and 2 to 6 inches in diameter.

In limited quantities this plant is grown here by Chinese gardeners, the total probably not amounting to more than 5 acres for the entire Territory.

**YAM BEAN ROOT** The yam bean root (*Pachyrhizus*) is cultivated to a very limited extent in Chinese gardens in Hawaii and is sparingly offered for sale in the

<sup>6</sup>Haw. For. Agr. 1916: 99.

<sup>1</sup>Haw. Exp. Sta. Bul. 60, p. 55, 1929. Two other species, also, are called yam: *Dioscorea esculenta* and *Dioscorea alata*.

city markets. The root is shaped somewhat like a large turnip or beet, is straw-yellow on the outside and white-fleshed within, and is of sweetish flavor, with consistency somewhat like that of the Irish potato.

**YARD-LONG BEAN** The yard-long bean (*Vigna sesquipedalis*), so-called because of its excessively long pods, is related more closely to the cowpea than to the common string bean. It is an Asiatic bean, grown in Hawaii chiefly for the Chinese trade. Production is limited.

See also "String Bean."

Ref.—Haw. Exp. Sta. Bul. 60:45, 1929.

**YERBA MATE** The yerba mate, a South American plant (*Ilex paraguayensis*), has in recent years attracted some interest in the United States in a commercial way. The leaves are used in the making of a kind of tea which is gaining favor as knowledge about it spreads.

The plant has been introduced for trial by the H.S.P.A. Experiment Station and flourishing specimens may be seen in its Manoa Valley grounds.





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